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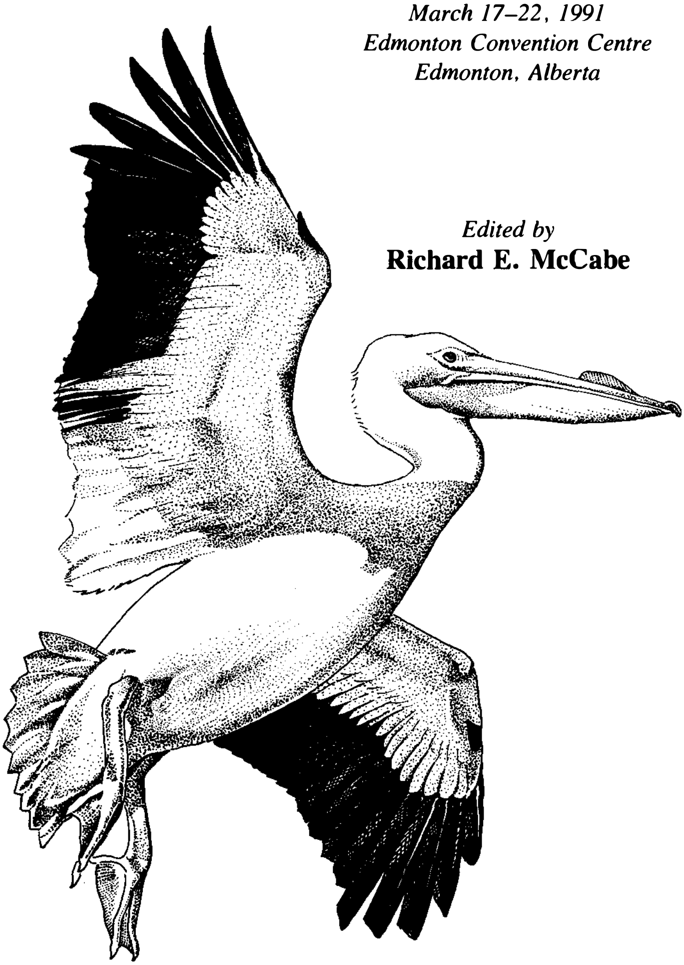

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Opening Session. *International Resource Issues and Opportunities*

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Norman, Oklahoma

Opening Remarks

Laurence R. Jahn
President
Wildlife Management Institute
Washington, D.C.

Welcome to the 56th North American Wildlife and Natural Resources Conference. We assemble here in western Canada to focus on "Sustaining Conservation: An International Challenge."

As human populations and technology continue to expand and dominate the landscape, more citizens express concerns and demands for habitats that perpetuate wild living resources, associated outdoor experiences and a reasonable standard of living—all elements of the quality of life.

These mounting, deep and genuine public frustrations and concerns in many countries, prompted the Secretary-General of the United Nations to establish the World Commission on Environment and Development in December 1983. Among the urgent calls for action were two: (1) to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond, and (2) to recommend ways concerns for the resource base could be translated into greater cooperation among countries to adjust relationships among people, their activities and the environment. The resulting report, commonly known as the "Brundtland Report," filed four years ago (20 March 1987) offers a major challenge. How do we change our ways to prevent resource abuse and safeguard the interests of current and future generations?

This question is not new. It has been faced repeatedly in histories of individual countries, as well as collectively with shared resources, such as through treaties dealing with migratory birds. This question erupts periodically because the pressing need is to establish and implement fully legal authorities that advance actions for governments to respond more effectively and fully to their public trust responsibilities for common property natural resources. And please remember, that includes four units of government—federal, state, local and native people.

Governments are charged with managing public resources for the public. They must do what is right to meet needs of the resource base and people. Personal ideas and agendas must be secondary to doing what is best in the public interest. As the Bruntland Report stated, sustainable development is the underlying principle for government natural resource policies. Uses of the land, water and wild living resources today should not damage prospects for future uses.

This concept and practice of resource stewardship—caring for the land and serving people—are highlighted this year, 1991, through celebration of the 100th anniversary of the U.S. National Forest System. That century record shows clearly how past devastations of vast forests promoted sportsmen, scientists and other citizens to acquire, restore, maintain and manage natural resources for the public good. That partnership action by the U.S. Congress and President Harrison on 30 March 1891 constituted a major benchmark in American conservation history. Of equal importance was acceptance that the nation's natural resources should be managed—an idea established firmly through the Organic Act in 1897. Now, with most national forests well-established, the challenge is to become involved in designing and implementing the USDA Forest Service's ecologically based forest management program. Called "New Perspectives," it has considerable potential for maintaining and enhancing habitats for wild living resources and providing sustained benefits for people in many countries, not solely the U.S. Far-reaching vision is required to plan and implement forest management strategies, for example, for neotropical birds breeding in North American forests and wintering in neotropical forests. You can gain insight on these new approaches at Wednesday's special session on forest management for the future. Hopefully, the new perspectives and information will help resolve the debates and court challenges facing forest management in many countries.

From those historic, founding initiatives of a century ago, similar positive actions have been taken to adjust the increasing volume of human activities to maintain functions and health of ecosystems for living resources, while simultaneously carrying out compatible economic activities. Examples illustrate significant changes in advancing sustainable development. Among Canada's examples is its approach to adjust people's activities to river systems and thereby reduce flood damages. Maps show designated areas subject to flooding to discourage flood-vulnerable developments. This type of prescriptive management is being used in more countries for vital common-property resources, such as floodplains, shorelands, coastal barrier resources and others—all with potential benefits for wild living resources, people and economic stability.

Among the heralded joint actions of Canada, the United States and Mexico are the Migratory Bird Treaties and their 1986 companion North American Waterfowl Management Plan. In five years, 12 joint ventures have been initiated, with 300 projects in various stages of implementation through a variety of partnerships. These international and national cooperative approaches and projects are testimony that people can work together internationally to restore and perpetuate essential and cherished natural resources.

As we near the end of this century, increasing concern and attention are being focused on aquatic areas. Accumulated information shows that aquatic areas, including wetlands of various types, are unique units of the landscape that contribute public services, products and values important to society. These areas make important contributions to the economy, standard of living and overall quality of life.

Engineers and economists have come to recognize that project planning and calculation procedures used in developments in the past often have led to inappropriate and bad decisions. Environmental (societal) costs of such decisions have been ignored for many decades. Thus, restoration costs (e.g., Superfund, pollution control, habitat restoration and mitigation) have continued to grow as the economy has expanded. As human population has increased and unbridled economic activities continue, positive accomplishments of the economy have become less evident and the destructive, degrading consequences more obvious. There is a growing sense of need for changes, even by many engineers and economists. These fundamental changes should be supported firmly to achieve adjustments in carrying out human developments and activities in ways designed to perpetuate aquatic areas.

Another pressing need is to establish a process that includes a rebuttable presumption that existing aquatic areas are invaluable, to be held in trust for the people, and that their physical, chemical and biological integrity must be perpetuated. Human activities, including water allocations, must be aligned accordingly. Any individual or group would have an opportunity to appeal and rebut the presumption. This approach would be reasonable, fair and help ensure continuation of public services, products and values from aquatic areas and other functional units of the landscape.

With the rebuttable presumption in place, throughout all levels of government, wetlands and other aquatic areas could be considered on multiple scales within the overall hydrologic units of river basins, watersheds, floodplains, shorelands, etc. With modern technology, such as used in national wetland inventories and the geographic information system (GIS), dealing with the largest to smallest scales is possible and reasonable.

President Bush already has established a no-net-loss policy for U.S. wetlands, and that also calls for a net gain in wetlands. The Domestic Policy Task Force on Wetlands is struggling to develop an approach and procedures to achieve those declared policy goals. Including the rebuttable presumption procedure would help the Task Force and the President implement this much-needed national policy.

Similarly, a positive, strong wetland policy will assist water development and management agencies to realign their missions, and incorporate more fully a coequal environmental quality and management objective.

Additional progressive actions are needed to strengthen water authorities and build a strong connector between land and water statutes to maintain the physical, chemical and biological integrity of aquatic areas. It is time to build upon innovative provisions of the U.S. 1985 and 1990 Farm Acts. You will recall that, in the 1980s, for the first time ever in U.S. history, a conservation dimension was woven into agricultural commodity programs. It included the conservation reserve, sodbuster, swampbuster and conservation compliance. A few months ago new provisions were added: low input agriculture (to reduce use of chemicals that degrade public waters); sustainable agriculture (to prevent and correct man-induced erosion); water quality maintenance and restoration (to come to grips with nonpoint source pollution); a wetland reserve (to maintain wetlands); and state technical committees (to design measures and practices to register accomplishments). Those provisions can be instrumental in designing prescriptions appropriate for management in different geographic areas.

The overall thrust is to develop programs that will lead to use of sustainable farming practices that prevent degrading surface waters and ground waters.

These U.S. advancements are paralleled in Canada's mid-1990 report seeking policy reform to integrate wildlife habitat, environmental, and agricultural objectives and practices on individual farms. These goals subsequently were supported by Canada's recently announced, multibillion dollar plan to conserve its air, water and land during the next five years. Included are standards to clean up, protect and enhance Canada's renewable natural resources. Increasingly, leaders of Canada, the U.S. and other countries are recognizing that a healthy environment is required to sustain economic conditions. Uses of the resource base must be aligned to be compatible with achieving those desirable environmental conditions.

While uses and management of the resource base have been carried out for centuries, those actions are being challenged severely today by a small, vocal, organized and well-financed group of people—extremists of the so-called ''animal rights'' camp. They oppose allowing people to use animals for any purposes and want tree-cutting prohibited. Governments mandated under the public trust doctrine of law to develop and implement sustained-use regulations and procedures also are being increasingly challenged.

Obviously, these positions and actions are considered radical, myopic and serious by many people, and they certainly disrupt rational uses of plants and animals. A number of organizations—including the International Association of Fish and Wildlife Agencies, The Wildlife Society, Wildlife Management Institute and the newly established United Conservation Alliance—are prepared to advance sustainable uses of fish and wildlife and counterbalance antimanagement proposals and actions.

The basic premise is simple. The human population now numbers in the billions. Each person is seeking a reasonable standard of living. To achieve it, plants and animals must be used. The challenge is to ensure that ethical, responsible, practical uses of plants and animals be permitted to continue.

Attend the session on animal rightists, as well as the other sessions. Participate fully, for it is from those discussions that other history-making progress can be stimulated and achieved. Following the 52nd North American Wildlife and Natural Resources Conference held in Quebec City in 1987, actions taken to correct and prevent acid precipitation in Canada and the United States illustrate further positive accomplishments in resolving international common property environmental problems. More such achievements are needed.

Welcome

The Honourable Leroy Fjordbotten
Minister
Alberta Forestry, Lands and Wildlife
Edmonton

Honored guests, it is my pleasure to welcome you to the 56th North American Wildlife and Natural Resources Conference. My Department is honored to cohost this prestigious conference with the Wildlife Management Institute.

I extend my warmest greetings to all of you and especially to those of you attending from out of province and out of country. In times of restraint and world uncertainty, I'm sure that many of you had difficulty getting approval to attend. Under these circumstances, it is heartening to see such a large North America delegation committed to the conservation and management of our wildlife and natural resources. I am confident that your stay here in Edmonton will be fruitful and productive. Judging from the conference agenda, your organizing committee is to be commended for the development of an exciting and challenging program. You will be discussing many continental issues, concerns and management strategies which are befitting of the conference theme "Sustaining Conservation: An International Challenge."

Along the lines of international challenges, I would like to express my sincerest appreciation to those of you here who had the foresight and conviction to conceive the North American Waterfowl Management Plan. Historically, this plan will be recognized as one of the corner stones to international cooperation in our common goal of sustaining wildlife and natural resources. Probably the most impressive feature to this plan is the multiplicity of partners. Having a network of international private and public agencies and organizations, complemented with the participation of individuals, landowners, farmers and ranchers, you have the key ingredients to success. Alberta's Buffalo Lake First Step Project is a good example of this. This project is supported by a number of states, the National (U.S.) Fish and Wildlife Foundation, Ducks Unlimited Inc., The Migratory Bird Conservation Commission, The North American Wetlands Conservation Council, Ducks Unlimited Canada, Canadian Wildlife Service, Alberta Agriculture, Wildlife Habitat Canada and ourselves. Alberta's delivery of land-based programs will be through a joint initiative between Alberta Fish and Wildlife Division and Ducks Unlimited Canada called Alberta Prairie CARE. This Wildlife habitat initiative, emphasizing soil and water conservation, will span the entire province, bringing significant benefits to rural Alberta. Alberta Prairie CARE will be the largest wildlife initiative undertaken in the history of conservation in Alberta. I am pleased to report that anticipated expenditures for this year's program are likely to exceed $16 million, of which 75 percent is from our friends in the U.S. and 25 percent from Canadian sources. Once again, I would like to acknowledge and thank the many U.S. agencies that have provided the leadership and resources to make the international cost-sharing agreement a reality.

Two other significant international challenges which will highlight the "90s" are the management of fish and wildlife resources in cooperation with our indigenous peoples, and the animal rights and welfare issues. Special sessions 6 and 7 will address these issues. I am confident that through the course of the discussions, many doors will be opened to resolving these complex issues.

On a national front, I would like to mention another vital achievement to sustaining wildlife in Canada. Last fall, my colleagues and I, the Wildlife Ministers' Council of Canada, approved "A Wildlife Policy for Canada." The goal of this policy is to maintain and enhance the health and diversity of Canada's wildlife, for its own sake and for the benefit of present and future generations of Canadians. The policy focuses on: (1) maintaining and restoring ecological processes; (2) maintaining and restoring biodiversity; and (3) ensuring that all uses of wildlife are sustainable. Of national significance, the policy provides a coordinated framework for federal, provincial, territorial and nongovernment policies and programs that affect wildlife. I look forward to its successful implementation. Copies of the policy will be made available to you during the conference.

In closing, I again welcome you to the conference. I encourage you to take advantage of this opportunity to discuss and actively share information and ideas with your colleagues. It is through this interchange that policies and programs for sustaining our valued wildlife and natural resources are formulated. To our Alberta visitors, I invite you to stay and enjoy our beautiful province. Albertans are proud of their wildlife heritage and are willing to share and experience it with you.

Buggy Whips or Partnerships: Choices for the Twenty-first Century

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

It is always an honor to participate in the North American. Before I begin today, I would like to take a moment and extend my personal regards and best wishes, and the collective appreciation of the U.S. Fish and Wildlife Service, to Larry Jahn for all the sage advice and solid support he has provided us over the years. Larry, your dedication, your accomplishments and your statesmanship in resource issues are a tremendous legacy—especially for so many of the students and younger members of our audience here today—the ones who will assume the leadership of conservation in the century ahead. Our sincere gratitude and appreciation to you.

You know, one of the axioms of the late 20th century is that the world is getting smaller all the time. The phrase first came into popular usage to describe advances in transportation technology, with the shift from ocean vessel to aircraft, and from conventional aircraft to jets to supersonic jets. Then there came the communication revolution and trans-Atlantic telegraph and telephone lines were supplanted by radio waves and now by satellite transmissions of sound, pictures and data virtually anywhere on the globe in an instant. I think this reality was brought home anew just recently with war in the Persian Gulf, where, via live satellite news feed, we were able to witness the fear and terror of an incoming scud missile attack. We all saw with great vividness how close and how immediate almost any part of the world can be. And we also saw in the Gulf War television coverage another image with compelling immediacy for all of us in this room—the pictures of dumped oil fouling coastal waters and killing marine life.

No one knows with any degree of certainty yet what the Iraqi oil dumpings may mean to the long-term health of the Gulf environment. There is, as there should be, international concern for this resource. There is also, I think, something of a universal recognition of how fragile the web of life is. It is still unknown what the smokey winds from Kuwaiti oil fires may do to the climate over the Indian Ocean; but the televised and computer-enhanced images of the plume trails across the region visually bear the notion of interconnectedness home again. The theme of this conference—Sustaining Conservation: An International Challenge—could not be more timely. The Gulf War may represent some acute environmental crisis, but once the fires at the sabotaged wells are doused and oil slicks dispersed, we must refocus our energies on the chronic and pervasive ills that pose grave threats to wildlife and their habitats the world over.

If there is a silver lining to those clouds from the oil fires, it could be that we will witness in this decade and in the century ahead a far greater degree of international cooperation as well as information and technology exchange, to sustain the Earth's wildlife communities.

I was very pleased last summer with the results of the largest US/USSR wildlife scientific conference to date. The conferees met at Washington & Lee University in

Virginia last June and produced a list of 22 recommendations for policy makers in both nations. One of their suggestions was both playful and, I believe, very perceptive—they recommended the establishment of an emergency "green phone" or green line to supplant the red phone of the cold war era. Its functional role would be to apprise each nation of an impending ecological catastrophe of great significance—another Chernobyl, for example. But its symbolic role is perhaps even greater—the increased exchange of information to protect and serve the environment.

I am happy to report that this year the Fish and Wildlife Service will host its largest contingent to date of Soviet scientists under our cooperative program which began in 1974. More than 120 Soviet scientists will team up with U.S. experts to look at topics such as polar bears, arctic nesting birds and contaminants in the polar environment, as well as further field studies on marine mammals. It promises to be a very busy and productive year. So extensive will our efforts be, in fact, that I believe we can say we are beyond the realm of just cooperation and very close to forging a true partnership for conserving the wildlife of the circumpolar environment.

In a similar way, our efforts with the Western Hemisphere Convention Program are providing increasingly important benefits. We have arrived at a point where the scope of our cooperative projects and programs is truly beyond the time available here for adequate description. Many of you are already aware of the wildlife training programs we are involved in with Mexico, Costa Rica, Venezuela and Brazil. I want to call attention to just one new effort—that is our new liaison office in Mexico to facilitate the growing number of cooperative activities with that country.

This past year was a very productive one for the Tri-Partite Committee in its work to conserve wetlands and migratory birds. The national wildlife agencies of Canada, Mexico and the U.S. recently began the first dozen projects in Mexico, which in turn, are being conducted by local Mexican institutions to promote the conservation of such vital wetlands as the Centla marshes and Alvarado Lagoon. It is also very gratifying to point out that the U.S. law known as the North American Wetlands Conservation Act is already at work substantially helping the activities of the Tri-Partite Committee with wetlands conservation in Mexico; and it is also providing some important assistance with wetlands efforts under the North American Waterfowl Management Plan here in Canada.

Speaking of the North American Plan, let me note just briefly in passing that this partnership—perhaps the very model for 21st century efforts—experienced what has to be regarded as a banner year in 1990, with equally bright prospects for this year. Even this briefest synopsis suggests what kind of scope we are now talking about:

- The first international habitat joint venture, the Pacific Coast, was established in California, Oregon, Washington and British Columbia. Thirty-seven states now are represented in the Plan. Work also is underway in two international species-oriented joint ventures—Arctic goose and black duck.
- Eighteen non-government organizations are now represented on the Plan's Implementation Board. In addition, more than 100 conservation groups are partners in joint ventures. More than 30 million people are affiliated with groups participating in the Plan.
- In the United States, seven habitat joint ventures have succeeded in protecting, restoring or enhancing almost 554,000 acres. More than 50 projects have been launched from coast to coast, and others will be underway soon.

- In Canada, the Prairie Habitat and Eastern Habitat Joint Ventures have protected or enhanced more than 35,000 acres.
- Private participation in the Plan has also increased. Some examples: The Deltic Farm and Timber Company agreed to help develop waterfowl habitat on 30,000 acres of bottomland near the Tensas River National Wildlife Refuge in Louisiana. The Scott Paper Company agreed with the U.S. Fish and Wildlife Service and the Alabama Game and Fish Division to expand management measures to benefit wildlife on 100,000 acres in the Mobile Bay area.

If, as I mentioned a moment ago, the North American represents a model for cooperation in the years ahead, how can we capitalize on its success—how do we adapt this successful formula—for conservation concerns other than waterfowl and their habitats? The array of resource challenges facing us right now is formidable. We are now in the process of mobilizing to conserve neotropic migrant species of birds; we are devising plans for the wisest use of coastal and estaurine resources; and identifying how state, provincial and federal agencies marshal their resources to better identify needs of non-game species and work to avert endangerment. None of these are small tasks and each raises special challenges and poses new questions.

Well, as the title of my talk—Buggy Whips or Partnerships—implies, we do have a choice. I think everyone can accept the value of a good partnership; and none would knowingly turn down an opportunity to really help improve conditions for wildlife. Obviously, no one would consciously opt for a buggy whip to propel their program into the next century. But, if there are metaphoric buggy whips out there that we should avoid, they would include these: doing things in resource conservation the same old way; avoiding new ideas and techniques; avoiding new audiences; and passively resting on the assumption that the public resource agency always knows best and will always have the last say in a matter. I think we have to recognize that we cannot go back to the mythic "good old days," if, in fact, they ever existed. Instead, I think we must focus on the most immediate task at hand—to rally informed and committed public support for sound conservation programs. That's going to take some effort and considerable creativity on our parts.

I think the natural resources community as a whole must embrace the reality that public agencies are indeed subject to market forces . . . or, stated another way, if resource agencies are aloof to mass market needs and perceptions, we can count on being ignored right back. A second point I think wildlife administrators must bear in mind is this: individual members of society want to feel as if they count; they want their viewpoint acknowledged; they want to have some choice in resource matters; and indeed, they are entitled to a voice. The third point to consider is that we are already seeing a trend where people—individuals, groups and whole communities—are seeking to empower themselves to do a better job of resource management right in their own locale. Linked to this is the movement by many resource agencies to try to get decision-making moved out of the central office and to where the resources are, to the lowest practical and feasible decision level. And a fifth and final point is that we should emphasize what works in resource management, what works out in reality. It's time to pay attention to outputs, not just inputs.

Now, these points I've just shared with you are not unique to the resource realm. And I certainly don't claim originality of authorship for them. Perhaps you recognize them as variations of some of the major trends emerging in business and government today, either under the mantle of Total Quality Management or New Paradigm. While names are important, and it always helps if they're catchy, my concern is that we use these principles to fully realize the opportunities they present us.

These really are exciting times in natural resource management. I'm very encouraged by some of the new programs we have underway at the FWS. I'm glad that so many of my colleagues in the Service are as excited as I am about our resource vision and where it can lead us. Most of all, it is tremendously encouraging to see the results of fairly new and recent partnerships, such as the North American Plan, and realize that what it has yielded is a great untapped potential for further goodwill and cooperation, domestically in the U.S., throughout North America and, perhaps, around the globe. Like many of you in this room, I am greatly concerned about preserving biological diversity on this planet. I would hope that you would share with me some optimism that sound partnerships may prove our best and surest vehicle yet to carry forth a full and rich biological community into the 21st century.

Sustainable Development through the Round Table Approach

George Connell
National Round Table on the Environment and the Economy
Ottawa, Ontario

I'm extremely pleased to be here today to take part in this important international event. So much attention has necessarily been drawn to the recent war, economic recession, and Canada's constitutional problems that issues such as those before us can sometimes be moved temporarily to the back burner. The War in the Gulf has once again reinforced the close linkage between the environment, the economy, and issues of war and peace. This conference will play an important role in refocusing our efforts back onto the topic of the environment as the foundation of economic and social systems worldwide.

I chair the National Round Table on the environment and the economy. Although Round Tables have been established across Canada at both the provincial and territorial levels, and in many municipalities, it is still a relatively new concept. Instead of bringing together individuals and groups that have common interests or goals, Round Tables reflect different backgrounds and experiences, different perspectives, and different values and beliefs.

However they do operate in the context of a common imperative. That is the challenge of integrating environmental and economic interests in our institutions and forms of decision-making, and sharing across all sectors the necessity to take responsibility for the way we think and do business. As members of a Round Table, we are given no legislative or regulatory power, and are not selected to be so-called "outside experts." Instead, we look to forging new partnerships for change, stimulating ideas and developing a broad consensus about what needs to be done and how it should be done.

In effect, we rely on the knowledge and experience of those who are most directly involved in, and affected by, the connecting issues of environment and economy. One of the primary roles of the National and Provincial Round Tables is simply to bring together the diversity of conflicting interests that are necessary to seek real, lasting solutions to sustainable development problems.

It was this approach to problem solving that motivated the National Round Table to convene a major forum on sustaining wetlands, about one year ago. The forum was the first major public event convened by the National Round Table and had two essential goals: first, to highlight the linkage between the environmental and economic significance of wetlands; and second, to break down the intersectoral barriers and foster the partnerships needed to find and implement practical solutions to the many problems related to wetlands.

I will return to this forum in a few minutes, but first it seems appropriate to review the context in which the forum took place and why we in Canada have a special responsibility in this area.

It's been estimated that there are about 1,400 million cubic kilometres of water on earth. Of that, about 97 percent is salt water, leaving only 3 percent of the total in the form of fresh water, and supporting most terrestrial life. Of the 3 percent of water that is fresh, over three quarters of it is locked into the icecaps that form the poles of our planet. Another 22 percent of fresh water is under our feet, in the form of groundwater. Of the remaining one-half of one percent of fresh water on earth, about 0.04 percent is in the atmosphere as water vapour at any given time, and 0.01 percent is flowing in our rivers. The remaining 0.35 percent is contained in lakes, swamps, and other wetlands. And the important point is that fully 24 percent of this scarce and valuable resource lies in Canada.

Like economics, in the natural world scarcity increases value. The tiny quantity of fresh water available to us in the form of wetlands is a scarce commodity of inestimable value. We know that the economic benefits of wetlands in Canada are over ten billion dollars per year in fish and wildlife, tourism, and recreational and other pursuits. But the value of wetlands to the underlying ecosystem in Canada is beyond the ken of economic measure.

Imagine for a moment the replacement cost of some of the services provided by the simple existence of wetlands. They act as filters to purify water; they break down pesticides and dilute the excess concentration of nutrients from human activity; they provide much of the water evaporation needed for rainfall and maintenance of normal weather patterns. Hundreds of species of birds, fish, mammals and plants are dependent on wetlands for their survival.

Think of the feats of engineering and construction necessary to substitute for the "free goods" provided by the natural occurrence of wetlands. Think now of the cost of producing these essential services. Consider the level of taxation necessary to perform this service for us. I think you see where I'm leading. Wetlands are invaluable to life on earth, and as they become more scarce, their value increases.

Unfortunately, wetlands and other wildlife habitats are under increasing development pressure both here in Canada and around the world. The plight of the rain forest in Central and South America have unfortunate parallels in the rate of loss of wetlands on the prairies and around some of our own municipalities and recreational areas.

The green plan, released late last year by the federal government in Canada, calls for the development of a five-part national wildlife strategy as well as the completion of the system of national parks by the end of the decade. Like you, I only hope that budgetary pressures and other problems affecting the federal government do not detract from meeting the commitments outlined in the green plan. I say this not only because of the importance of reaching Canadian environmental goals, but because of Canada's responsibility to demonstrate to the international community that progress can be made.

Thanks to generations of hard work and commitment, Canada is one of the richest nations in the world in terms of per capita income and quality of life. We are also stewards over the second-largest land mass in the world, much of it highly sensitive to human disturbances. What we do in Canada, and how we do it, is being watched by other nations with similar problems and fewer resources to deal with them. If, with all of our educational, economic and natural advantages, we cannot work together to resolve our environmental problems, surely we will have little to contribute to global solutions. Indeed, we would lack the moral authority or credibility necessary to encourage others.

Fortunately, there are many optimistic signs of progress. The North American

Waterfowl Management Plan was signed between Canada and the United States in 1986, adding Mexico as a signatory in 1989. This innovative and cooperative approach to restoring waterfowl populations involves securing over 4 million acres of wetland habitat across Canada, and will invest about $1 billion in this country alone.

I am convinced that this enormous investment in wetlands and wildlife will bring tremendous benefits to many other areas of the Canadian economy and society. Agriculture, recreation and tourism, forestry, water quality and quantity, rural communities and urban centres alike will benefit from the renewal of wetlands in North America. But to be successful everyone must do their part. It is the thousands of small changes that ultimately make the difference.

The National Round Table, of course, is not a major player in wetlands retention and restoration, nor has it an important contribution to make in the management of wildlife habitat. Yet there are important steps that we can take to assist others in their work.

One issue that the Round Table continues to address is the acceptance of personal and organizational responsibility for actions that impinge on the environment. In this country, we have developed a pattern over the last two or three decades of turning to the various levels of government whenever we have a problem and saying, in effect, you fix it. We then express our disappointment with subsequent programs and policies by blaming bureaucrats and rejecting the politicians we elected to solve our problems. Rather than taking direct responsibility for changing our personal or business activities, we try to fix the responsibility, and, hence, the blame on others.

Increasingly, however, this attitude is changing as we all come to recognize that protecting the environment is everybody's responsibility. As attitudes change it becomes ever more important to provide information that enables people to act on their newly discovered responsibilities. I think any group with an interest in environmental issues should make public information and educational activities one of their highest priorities. The more we can engage in public, the more opportunities to create the partnerships and coalitions needed to move in the direction of ecologically sustainable economic development.

The many dedicated and effective non-governmental organizations working for wildlife is a tribute to the power of the ordinary citizen. The Nature Conservancy, Wildlife Habitat Canada, Ducks Unlimited, The Canadian Wildlife Federation, The Audubon Society, The Izaak Walton League and so many other groups continue to show real, practical results. Forming partnerships with local, provincial (or state), and federal government agencies can illustrate the adage that the whole is greater than the sum of its parts.

And this leads me back to the sustaining wetlands forum. I would like to tell you about it and how it worked, because I think it is a model that can be effectively applied in other jurisdictions, and in other issue areas.

The National Round Table convened the forum, but the event was in large measure planned, sponsored and delivered by the partners themselves. Ducks Unlimited Canada, Wildlife Habitat Canada, and two different sections of Environment Canada were the key partners in initiating and making the forum a success, but many other groups contributed mightily to the effort. The forum focused on the integration of soil, water and wetland conservation initiatives and how a coordinated approach could provide the broadest possible environmental and economic benefits to Canada. Obviously, agricultural, municipal, business and environmental conservation groups needed to work with federal and provincial government agencies to find solutions in the best interests of all the parties.

The forum worked. It showed that quite different perspectives on an issue can be brought together in a dialogue that leads to practical and effective recommendations in the interests of all the parties and that can be implemented most effectively by those parties. The 70 plus recommendations from the forum covered most areas of significance related to wetlands management, including changes to policy and legislation, taxation issues, public awareness and information programs, codes of practice, and land use issues.

Perhaps the most important conclusion from the forum was that resolving environmental issues is not just the responsibility of government, but must include all the representative groups and interests. None of the workshops at the forum concluded that everyone should sit on their hands and complain about government inaction. All of the workshops targeted many of their recommendations at themselves, each taking some part of the responsibility for solving the key problems.

This attitude is reflected in the type of recommendations that came forward. A common thread is that they do not require significant amounts of new funding or government programs to be put into place. What is required, however, is that there be continued cooperation of the partners in a coordinated effort to address the issues in an integrated manner.

This may sound like simple common sense, but it is not the usual mode of operation in this country, and I expect the *situation* is similar in other nations as well. Sharing the turf, surrendering some control, and reallocating responsibilities in order to get results is not easy. It takes an innovative attitude; it involves taking some risks; and it makes for a messy process. But we at The National Round Table believe that it also leads to lasting results. When outcomes are shaped by those who will be most affected by them, and all have an influence on the final decision, both responsibilities and benefits are established. Gaining acceptance of both ends of the bargain is what assures a successful outcome.

The NRTEE's role is to promote a partnership approach to sustainable development. That is what we did in convening the sustaining wetlands forum, and we are delighted that the agricultural, business, local planning and conservation partners who attended have recognized the importance of continuing to cooperate and have picked up the ball and run with it.

We have learned that this approach is finding adherents outside Canada. We are told, for example, that the results of the sustaining wetlands forum played a role in developing a draft strategy to stop and reverse the loss and degradation of Mediterranean wetlands. As well, that the partnership approach used at the forum itself will be used as a model process for follow-up actions in that part of Europe. We believe and are beginning to demonstrate, that by bringing together the various interested parties to work out common solutions, the development of policy that is acceptable to all parties can be fast tracked and that acceptability through participation is the key to implementing policy.

So the forum worked as far as it went. A series of balanced recommendations representing the many interests at the table were put forward. The question then becomes, what actions are being taken? We are delighted to hear that many of the recommendations are being addressed by activities sponsored by federal, provincial and territorial government agencies, round tables, and many private sector groups.

Several of the organizations that participated in the forum have followed through and have begun to implement the recommendations addressed to them.

For our part, the Round Table's catalytic role would normally end when the partners that we have helped bring together take ownership of the process and follow through on their own recommendations. As you can appreciate, there are many other issues and constituencies that demand our attention and, unfortunately, we have set limits on the degree to which we can continue to be involved in an issue once we have set the ball rolling.

However, given that the forum was the first national event through which the Round Table promoted its partnership approach, we asked the North American Wetlands Conservation Council to conduct an evaluation of the forum recommendations, identify appropriate implementation strategies and report back to us on what further action, if any, might be required of the NRTEE.

It is with great delight that we have since learned of the imminent formation of the Canadian Wetlands Conservation Task Force. This new partnership, set up by the conservation council, will be taking our request for any evaluation of the forum recommendations significantly further. It will, in fact, be developing the implementation strategies and acting on the specific forum recommendations originally addressed to the Round Table.

We see this as a progressive step that will produce results much faster than would otherwise have been the case since the work of the task force has the benefit of the best experts and managers in the country, as well as multi-sectoral participants.

Mr. De Cotret, the federal minister of environment and, by the way, a member of the National Round Table, is to be congratulated on the initiative that his Wetlands Conservation Council has shown in moving this agenda item ahead. The Round Table looks forward to being kept apprised of progress through periodic reports from Mr. De Cotret.

We feel that we have achieved one of our goals by having played a small, but we hope significant, role in bringing new partners into the consensus around sustaining wetlands. The process of implementation is in the best possible hands and our attention must now turn to other equally important issues.

You should know, however, that the success of the partnership approach demonstrated through the forum has led the Round Table to apply the same principle to a series of dialogues that we have launched with the energy, forest and tourism sectors.

So you see, not only do we and our sister Round Tables in Canada seek converts to the "Partnership Faith," but we live by it ourselves. I invite all of you to see it as a context in which to face the international challenge of sustaining conservation.

Centennial Commemoration of the USDA Forest Service

James R. Moseley
Assistant Secretary, National Resources and the Environment
U.S. Department of Agriculture
Washington, D.C.

It is a great pleasure to be here in Canada. I'd like to thank the Wildlife Management Institute for extending this invitation to talk with you today about the management of our natural resources, and to celebrate the 100th anniversary of the National Forest System.

It's nice to see such a fine turnout here today. It reminds me of the time Winston Churchill was asked if he didn't get impressed with himself because every time he gave a speech he packed the hall. "No," Churchill said, "Every time it starts going to my head, I just remind myself that if, instead of giving a speech, I were being hanged, the crowd would be twice as large."

That's equally true for government bureaucrats, particularly if you are one dealing with environmental issues. It's nice to be asked to go somewhere rather than be told where to go.

Today, however, rather than dwell on the negative side of the environmental issues, I want to spend the next few minutes talking about something positive; something each and everyone of us can take pride in; an idea that was born 100 years ago; an idea that has withstood the test of time.

It was an early spring day, March 3, 1891, not unlike today. But, the world was a much different place. Women were creating a stir with their divided skirts and knickerbockers they wore for biking. There were more soda fountains than saloons in New York City. Carnegie Hall opened its doors. Basketball was invented. The United States had overtaken Britain in steel production. And the average income in America was $430. A house cost $2,000 and a loaf of bread cost a nickel.

The industrial revolution was taking place all across the country. The national euphoria of continental expansion and growth was at its peak. Farmers, like my great-grandfather, were breaking sod; herds of cattle and sheep were grazing the grassland; lumbermen were clearing the way toward the west; and railroads were linking East to West.

Ownership and staking your claim was the spirit of the times, with little heed to the rules of fair play or the needs of the future. But for a few of those pioneers it was apparent that our nation's forests represented a great but vulnerable national asset that, for the sake of posterity, should be protected.

On March 3, 1891, John W. Noble, Secretary of the Interior, convinced a weary group of legislators working past midnight to add a rider to an already mammoth land bill, giving the President the power to create forest reserves.

President Benjamin Harrison, 100 years ago this month, signed the Creation Act and immediately set aside 1.24 million acres that surrounded the Yellowstone park Timber Land Reserve, today known as the Shoshone and Teton National Forest.

This event, with little fanfare, turned out to be what history books have called the watershed event in American conservation history and the birth of our National Forest System.

Today, 191 million acres are a part of the National Forests. And today, just like 100 years ago, our President, George Bush, our new Secretary of Agriculture, Ed Madigan, the men and women of the Forest Service, and I are committed to the conservation cornerstone of wise and balanced use of our natural resources.

President Bush, whose personal love of the outdoors is well-known, has made conservation a major priority of his Administration. He is a champion of the environment in the great tradition of Benjamin Harrison and Theodore Roosevelt. He articulated his environmental visions when he said: "True global stewardship will be achieved not by seeking limits to growth, which are contrary to human nature, but by achieving environmental protection through more informed, more efficient and cleaner growth."

The President's commitment to the enhancement of our natural resources can be seen: in the recent passage of the Clean Air Act, promising major improvement to America's air; in the "The America The Beautiful" program, providing opportunities to plant trees for America; in improved outdoor recreation opportunities through creative private and public conservation partnerships; and at the international level, the proposed global forestry convention as a part of UNCED talks to be concluded in Rio De Janeiro in 1992.

These initiatives, along with many others the President has undertaken, are the foundation for a solid environmental program. A program that allows for economic growth to meet our society's aspirations, but also to protect our environment so that we may enjoy our good fortunes and pass the opportunity for prosperity on to future generations.

President Bush has also made a strong commitment to the national forests. Just last year, he submitted to Congress his Renewable Resources Program—a long-term strategic plan for the U.S. Forest Service.

As our society continues to prosper so will our demand for increased uses of our natural resources. There is clear recognition we will not be able to meet all these needs if we do not invest in the continued careful management of these resources.

The 1990 RPA program is a bold, strategic plan for conservation and wise use of our national forests and grasslands. This strategic plan features four high-priority themes the Forest Service will focus on over the next 5 to 10 years. The four priorities are:

1. enhancement of recreation, wildlife and fisheries;
2. environmentally sound commodity production;
3. improvement of our scientific knowledge; and
4. improvement of resource management globally.

The RPA program is the cornerstone of a plan that reinforces a better balance among the use of resources while enhancing the quality of the environment. It illustrates our renewed commitment to multiple-use management—a philosophy so wisely passed on to us by our great forefathers.

But as you know, none of these programs will be successful without a commitment not only from the Administration and the Forest Service, but also a commitment from the American people. We learned a long time ago in the Forest Service that successful programs are built on solid partnerships; partnerships like we have with our state foresters and such outstanding organizations, as the Wildlife Management Institute.

This ambitious program for the Forest Service, especially in the context of today's intense competition for federal dollars, will not happen without these strong partnerships. We must rely on our existing partnerships and forge new ones between the public and private sectors on the local, national and international level.

President Bush will be remembered in history for many things, but one thing in particular that will be a lasting legacy is his strong belief in the people and our ability to get the job done, to overcome adversity, to help our fellow man. He calls us the "thousand points of light."

Our job as natural resource managers is to provide the leadership and guidance to all those thousands point of light (and, I might add, a thousand points of view) so we can assure a continuous supply of natural resources and a healthy environment for future generations.

Numerous public opinion polls indicate the public believes taking care of the environment is a top priority. The people are ready to roll up their shirt sleeves and get to work. Our challenge is to focus this energy on finding solutions and taking advantage of what I believe is a teachable moment.

One of the things not mentioned in my introduction was that I am also a father of seven children. And as you know, some of life's most important lessons can be learned through raising children. One of the things I've observed is that learning doesn't occur evenly on a straight trend line. There are special times when things seem clearer to us than moments before.

For example, three of my seven children are teenagers. And with teenagers you learn from experience there are times when you can talk and talk to your children and nothing happens. They don't listen. And then there comes that moment when they make a mistake, one serious enough that they really have no choice but to accept what you say. You know at that point in time you have one of those "teachable moments" in life.

I happen to believe we are a "teachable moment" in our history relative to environmental issues. It's appropriate for this teachable moment to come during the 100th anniversary of our National Forest System. I hope that each of you will join us in the Forest Service in celebrating this historic event. This centennial gives us an opportunity to celebrate not just the success of the forest system, but more importantly, it provides us a solid foundation to propel us into the 21st century.

The people of the North American continent are among the richest in the world. Yes, we can talk of richness as financial wealth, and certainly even there we are. But I want to speak of richness of a different kind. Rich in culture, rich in spirit and rich in natural resources. These resources have served us well and, as we begin our second 100 years, we raise our consciousness and commitment to their conservation and well-managed use.

The Next 100 Years of National Forest Management

F. Dale Robertson
Chief
USDA Forest Service
Washington, D.C.

Introduction

First, I want to thank all of you here at this conference for joining the USDA Forest Service in celebrating 100 years of conservation on the National Forests.

It all started 100 years ago when the Yellowstone Park Timberland Reserve was set aside from the public domain. Over the last 100 years, the National Forest System has grown to represent about 8.5 percent of the United States.

The two organizations most responsible for getting the Forest Reserves established were the American Forestry Association and the Boone and Crockett Club.

The Boone and Crockett Club was very concerned about declining wildlife numbers, especially big game in the West. Because of this, they became strong advocates for forest reserves. Without the Boone and Crockett Club's strong support on behalf of wildlife, and translating that into effective political action in Washington, D.C., there might not be a National Forest System today. And, even if there was, it would likely be different and smaller.

I think it's important to remember, especially those of us in the Forest Service, that wildlife management was one of the original reasons for our existence.

I believe if those early conservation leaders returned today, they would be pleased to learn that the National Forests are the home of:

- about 50 percent of our big game animals;
- about 70–80 percent of our elk, bighorn sheep and mountain goats;
- about 50 percent of our cold water fisheries;
- about 50 percent of our salmon/steelhead spawning and rearing grounds on the West Coasts; and
- more than 200 threatened and endangered species, some of which would just not make it without the national forests.

I think those early conservation leaders would say it has been a good 100 years with many "ups and downs" along the way, e.g., we went from nearly wiping out certain species, like the wild turkey and elk, to almost full recovery. I think they would compliment the wildlife and fisheries community for a job well done, but say that we should do better in the next 100 years.

Looking Ahead—The Next 100 Years

In looking ahead to the next 100 years, there are certain basic principles that I believe should be followed in management of the National Forest System.

First, I believe we should look for and seek out the wisdom of our great leaders of the past—our conservation heroes.

I would like to highlight three of those heroes who were also Forest Service employees at least during part of their careers.

1. *Gifford Pinchot*—Father of American forestry and first chief of the Forest Service. His philosophy was "conservation and wise use of natural resources for the greatest good, for the greatest number of people over the long run." He overlaid that basic philosophy with a strong "public service attitude." His philosophy, more than any other, has shaped the multiple use management of the National Forests during the first 100 years. I believe it is still the right basic policy for the future, but with some important differences from how we have practiced in the past.
2. *Aldo Leopold*—One of those important differences we're making is keyed to the philosophy of Aldo Leopold. He is the father of wildlife management and could also be called the father of ecology. Leopold's philosophy was rooted in a strong land ethic. He defined conservation as "a state of harmony between people and land." He said "the first precaution of intelligent tinkering is to keep every cog and wheel." That's important advice as we deal with complex issues of biological diversity and threatened and endangered species. I believe Aldo Leopold's philosophy needs to play a more prominent role in our thinking about the future management of the national forests.
3. *Bob Marshall*—I think the same is true about another conservation hero—Bob Marshall, the father of wilderness. Marshall focused on the spiritual values and natural beauty of the forest. He described "wilderness as a perfect aesthetic experience." Today one-sixth of the National Forests is in the wilderness. We can't ever forget Marshall's philosophy because many people today view the forests primarily for their spiritual and aesthetic values—and those values are important to our future.

So, as I think about the philosophy to guide the next 100 years of management for national forests, I would put together an interdisciplinary team consisting of Gifford Pinchot, Aldo Leopold and Bob Marshall, and ask them to blend their philosophies into a new mix, reflecting a balance among their views.

Since these three heroes are no longer around, we have to do it for them by using the thoughts they left behind. We may also need to add a little here and there to round out and update their philosophies to reflect today's reality.

I think the end results would be something like: "a multiple-use philosophy built around ecological principles, sustainability, and a strong land stewardship ethic, with a better recognition of the spiritual values and the natural beauty of the forests."

To that philosophical base, I would blend in three more key ingredients:

1. A stronger partnership with people in getting their views and values better incorporated into our thinking and management;
2. The tremendous scientific knowledge base which we have gained through research/experience over the past 100 years. Furthermore, I would expand that scientific knowledge base and accelerate its application on the ground through a much closer partnership between land managers and scientists;
3. Finally, a heavy dose of conservation partnerships, like never before!

Conservation partnerships

Together, we are making great progress in conservation partnerships. It is the one thing that I believe the current generation of conservationists are doing better than anyone has ever done before. Moreover, I believe that "conservation partnerships" will go down in history as this generation's most important contribution to the conservation movement.

Last year, we had about 1,700 partners helping us get the fish and wildlife job done on the national forests. It's those partnerships that make the difference between doing a mediocre job and an outstanding job for wildlife and fisheries.

We really appreciate every one of our 1,700 partners. I would dearly love to recognize all of them and say thanks to partners like the state fish and wildlife agencies, Wildlife Management Institute, Rocky Mountain Elk Foundation, National Wild Turkey Federation, Ducks Unlimited, Trout Unlimited, Quail Unlimited, Sports Fishing Institute, Boone and Crockett Club, and many, many more.

We in the Forest Service want to thank you for making a big difference in the quality of wildlife and fisheries management on our National Forests.

Closing

So, when I add up all these points, I get:

1. A different blend or mix of the Pinchot/Leopold/Marshall philosophies, with definitely a stronger Leopold flavor;
2. Better use of our scientific knowledge and experience to manage the National Forests on an ecological basis;
3. Better partnerships with the American people; and
4. Expanding conservation partnerships.

This gives us something that we in the Forest Service call "new perspectives in managing the National Forests."

In some ways, you could call it "old perspectives," because we are going back to the philosophies of our early day heroes and putting them in the context of today's scientific knowledge and social/political situation, plus pushing partnerships far beyond anything we've ever experienced before.

Those are the principles that I believe we ought to follow in managing the National Forests for the next 100 years.

I am optimistic and filled with hope about the future of wildlife and fisheries and all other resources on the National Forests, especially if we all work together in partnership.

Presentation of the 1991 Guy Bradley Award

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

Crimes against wildlife occur 365 days a year. The poacher doesn't keep a nine-to-five schedule, but will likely work at night or on the holidays. Foul weather that grounds aircraft is likely to lure the outlaw gunner out. These are the hours and the weather conditions under which the law enforcement officer works. Chronically understaffed and vastly outnumbered, the law enforcement agent, state or federal, represents a "thin green line" to conserving this nation's fish, wildlife and plant resources for future generations.

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

The Foundation is honored to present the 1991 Guy Bradley Award to Colonel Robert M. Brantly, of the Florida Game and Fresh Water Fish Commission, and David L. Hall, of the U.S. Fish and Wildlife Service. Picked from a field of outstanding nominees, these two professionals more than meet the award's qualifications. They were selected by a volunteer panel of judges comprised of representatives from federal and state wildlife agencies, and conservation organizations.

Bob Brantly—Florida Game and Fresh Water Fish Commission

Bob Brantly's career in wildlife law enforcement began in 1957 as a wildlife officer for the Commission. Bob progressed through the ranks until 1977, when he became the Executive Director of the Commission, a position he still holds. Under Bob's direction, the Commission has undertaken new approaches to lessen adverse impacts on fish and wildlife habitats. Some innovative measures include: (1) establishing one of the nation's first wildlife undercover investigations units; (2) implementing a citizen-report program called Wildlife Alert; (3) assigning Environmental Law Enforcement Investigators to apprehend not only wildlife law violators, but to enforce against other major environmental crimes as well; and (4) implementing a dog-detection unit for wildlife law enforcement.

In a state known for its rapid growth and development, Colonel Brantly has demonstrated strong leadership skills, especially evident in times of controversy. A staunch advocate of sound wildlife management practices, Bob has forged successful campaigns on tough resources issues ranging from emergency deer hunts in the Everglades to resolving the lead/steel shot controversy. Bob has shown himself to be tough, articulate and effective on behalf of the natural resources in Florida. Under the leadership of Bob Brantly, Florida's wildlife officers continue to excel and to be recognized as respected professionals in the field of wildlife law enforcement.

Dave Hall—U.S. Fish and Wildlife Service

Dave Hall began his distinguished career with the U.S. Fish and Wildlife Service in 1962, after he received his Masters degree in wildlife management from Mississippi State University. Dave became a special agent in 1965, was promoted to supervisory special agent for seven southeastern states in 1972 and, in 1987, earned his current title of special projects officer. Dave's numerous accomplishments include: (1) introducing the technique of using cannon nets to band waterfowl on the Canadian prairies in the 1960s; (2) helping to expose the illegal trade in American alligator skins in the early 1970s; (3) conducting successful investigations into the Alaskan black market in walrus ivory and polar bear skins; and (4) leading many undercover investigations in illegal waterfowl hunts, the videotapes of which many of you have seen on the evening news.

Dave's greatest contributions to wildlife law enforcement may be his ability to bring wildlife crimes to the attention of the general public through the media, and his ability to foster cooperation between sportsmen, judges, prosecutors and his fellow conservation officers. Under his direction, this cooperation has resulted in the prosecution of more than 1,000 individuals per year for 16 years in Louisiana Federal Courts. Throughout his career, Dave has committed himself to proving the importance of law enforcement as a wildlife management tool. In addition to being interviewed on television news shows like "20/20," Dave has developed and taught related courses at the Federal Law Enforcement Training Center in Glynco, Georgia, at Louisiana State, Loyola University and Mississippi State, where he is currently working on his Ph.D. Not surprisingly, his thesis examines illegal waterfowl harvest and hunter responsibility in the Lower Mississippi Flyway.

The Award

In recognition of Bob and Dave's efforts on behalf of wildlife conservation, the National Fish and Wildlife Foundation is pleased to present them with the Foundation's 1990 Conservation print and commemorative plaque, together with checks for $1,000.

The Foundation applauds Bob Brantly and Dave Hall, and the hundreds of other dedicated wildlife law enforcement officers who also deserve this recognition. The Foundation would like to thank John Doggett, Terry Crawforth, Gary Myers, Ken Goddard, Terry Grosz, Larry Jahn and Max Peterson for their willingness to serve as Guy Bradley Award judges. Finally, our thanks to the Wildlife Management Institute for its help in this presentation.

Special Session 1.
Wildlife Conservation in National Parks

Chair
FREDERIC H. WAGNER
College of Natural Resources
Utah State University
Logan

Cochair
CLIFFORD J. MARTINKA
U.S. National Park Service
Glacier National Park
Kalispell, Montana

A Brief History of Wildlife Conservation in National Parks

C. J. Martinka
Glacier National Park
West Glacier, Montana

Welcome to this first of two special sessions sponsored and organized by The Wildlife Society. Our goal for these sessions is the technical exploration of contemporary issues in wildlife management. This afternoon, *Wildlife Conservation in National Parks* will be discussed by distinguished authorities from Africa and North America.

The creation of national parks is viewed by many as inherently beneficial for the conservation of wildlife. And few would argue that protection provided by national parks has not contributed to the maintenance of wildlife diversity, especially where humans dominate our rapidly disappearing natural landscapes. Be that as it may, park management of wildlife has been and continues to be a controversial and challenging issue.

History reveals that professional controversy over the management of national park wildlife may be relatively recent phenomenon. I base that judgment on the earlier years of this century when park programs tended to follow widely accepted wildlife management principles. Some species were considered favorable and provided with food during times of hardship. Other species were thought to be less than desirable because they preyed on the favored: they were controlled or eliminated. But when the favored increased and their habitat diminished, they too required management.

Controversy as we know it today had its roots in the latter stage of park wildlife management. Artificial feeding and predator control had largely passed into history by the time control of favored species seemed necessary. The killing of popular animals such as elk brought public sentiment into the park wildlife management picture. To complicate matters, some wanted the killing stopped, while others wanted to participate in the process. For at least a few wildlife scientists, there now were cultural reasons to search for options to sustained harvests of park wildlife.

Public interest in park wildlife management accompanied a more general awareness in the environment and its needs. Ecosystem research was accelerating: the concept of self-regulating natural systems was being explored. As examples of natural regulation emerged in the scientific literature, there was thought that the concept held potential for the management of wildlife in national parks. As the idea gathered support, new controversy emerged in the form of intense disputes among professional wildlife managers and scientists. Experimental management became one means of addressing the myriad questions that were raised—it too was controversial.

The conservation of natural landscapes carried management beyond single species and into the realm of ecosystems. Predators were viewed as legitimate contributors to natural processes, but questions about their ability to control wildlife populations remained unanswered. At the same time, the undesirable effects of exotic species led to reduction or removal in many parks. Colonization, extinction, diversity, isolation and viability gradually entered the vocabulary of those interested in park wildlife management.

More recently, human dimensions have been added to the increasing complexity of park wildlife management. For example, some species harbor parasites and disease that can be transmitted to humans and domestic animals. Others are dangerous when confronted, or rapidly habituate to people and their handouts of tasty food. And as our society evolves toward an urban culture, wildlife values and the management set in place to address those values are changing. We already see this in the various groups that are directing their efforts toward the humane treatment of animals. These and other issues will likely intensify as human numbers continue to increase and encroach upon park boundaries.

Finally, there is a fundamental question relating to the role of national parks in future environments. One school proposes that national parks are cultural resources to be conserved in a manner that benefits all of society. An opposing view holds the national parks are unique natural resources that should be conserved for their inherent ecological, educational and scientific values. The divergence of these viewpoints is a major obstacle for managers seeking to establish goals and objectives for wildlife. And controversy tends to persist where there is no agreement on desired conditions for wildlife and its habitat.

Controversy is a normal part of both the democratic process and the scientific method that we apply to the management of our public lands and resources. It functions in a fashion that generally assures full exposure of facts, opinions and positions relating to any particular issue. In that sense, I propose that controversy is a valuable contributor to the issue of wildlife management in and around national parks. Our responsibility as administrators, managers and scientists is to learn from controversy and apply its lessons to the challenges that we face.

Management of the Kruger National Park: Principles, Policies and Strategies

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Introduction

For probably as long as some form of nature conservation has been practised, conservationists have been divided on the issue whether or not to manage such areas. This is a debate that has been conducted across the board, irrespective of the wide range of objectives and circumstances applicable to different conservation areas.

In several cases, protection has led to the increase in animal populations and resulted in the dilemma whether or not the numbers of such animals should be artificially checked (Jewell et al. 1981, Owen-Smith 1982). Similar arguments have also revolved around the question of applying bush fires, the provision of artificial watering points, disease control and virtually every other form of man's involvement in guiding natural processes. At times, differences have led to sharp exchanges and have even resulted in questions raised on what may be considered "natural." In the wide spectrum of what may be classified as conservation areas, with specified objectives differing from one area—or level of conservation status—to the other, ample provision is made for the accommodation of both points of view.

Without attempting to appease both sides, the National Parks Board of South Africa (NPB) has adopted the philosophy that some form of qualified management may be imperative if it is to succeed in its primary objective of preserving natural ecosystems in their most pristine state possible. It is accepted that in all but highly exceptional cases the ecological composition and processes of natural ecosystems have been affected in one way or another by the activities of man. And where the preservation of their pristine qualities is of prime importance, it can only reasonably be achieved if amends are made to counter the disrupting influences.

Principles

A vast number of categories have been identified by the International Union for the Conservation of Nature (IUCN) to accommodate conservation areas to meet an equally divergent set of objectives (Dasmann 1973). Many of these categories also coincide with the various tiers of local, regional and national government responsible for their proclamation. In this respect a national park is therefore defined as— "a relatively large area:

(i) where one or several ecosystems are not materially altered by human exploitation and occupation; . . .
(ii) where the highest competent authority of the country has taken steps to prevent or eliminate as soon as possible exploitation or occupation; . . . and
(iii) where visitors are allowed to enter, under special conditions, for inspirational, educative, cultural and recreative purpose" (Anonymous 1975).

The NPB fully endorses the conceptual guidelines set by the IUCN. In its policy statement the NPB clearly states that:

(1) "The South African system of national parks should represent all the most important nature assets in the country; . . .
(2) "Each national park should be extensive enough, or be capable of sufficient expansion, to serve as an excellent example of one or more natural ecosystems, in a well-preserved state, which in the South African context may be regarded as of national importance; . . .
(3) "National parks are protected by statutory legislation and managed by the National Parks Board of Trustees in accordance with the National Parks Act, in such a manner that the natural environment and all its essential features shall be preserved; and . . .
(4) "The management of a national park is carried out strictly in accordance with guidelines formally set forth in a management plan notified by the Board, made available to the public and embracing all activities carried out within the boundaries of the park . . ." (Anonymous 1986).

Both in the guidelines set for national parks by the IUCN and the policy statement by the NPB much emphasis is placed on the preservation of pristine ecosystems as the most essential objective of national parks. By the various definitions given to ecosystems they imply discrete ecological units in which the interdependent components interact with one another to give the units their own particular characteristics. In accordance with conservation philosophers, e.g., Leopold (1975), the NPB subscribes to the concept of life in terms of ecosystems and has defined life as ". . .the sum total of a number of interacting and interdependent processes that relate to one another in a spontaneously dynamic fashion, with the inherent capability of reproducing and perpetuating their specific form of life" (Joubert et al. 1985).

In accepting the concept of life as its basic philosophy towards the preservation of ecosystems, the following guidelines have been identified for consideration in the formulation of management strategies:

(1) the harmonious interaction and interdependency of the processes involved;
(2) the importance of maintaining the fully functional (dynamic) aspects of those processes;
(3) the resilience to accommodate change and the mechanisms involved in maintaining stability;
(4) the cyclic nature of the processes; and
(5) the mechanisms and adaptations involved in ensuring the survival of the organisms (Joubert et al. 1985).

Essentially, therefore, management priorities are aimed at preserving structural and species diversity, and maintaining life support processes. Structural diversity relates not only to the physical environment, but also to plant and animal communities through their response to varying climatic and geomorphological conditions. Variations resulting in structural diversity include species composition and population structure, where structure reflects differences in growth forms (shrubs/trees) and relative densities and distribution patterns.

Management considerations to conserve structural diversity may arise from boundaries which arbitrarily cut through ecosystems, thereby reducing available habitats and restricting/influencing seasonal distribution patterns and/or migration routes. Disturbances may also arise from an injudicious road network, water provision program, veldburning and culling operations.

Species diversity results from the characteristic species composition which is peculiar to particular biotic communities, as determined by the nature and availability of habitats. Changes to the species composition of a community are therefore closely related to changes in habitats and may result from temporary (cyclic) changes induced by climatic cycles or a more permanent loss of species due to induced disturbances of the habitat (often originating beyond the borders of the conservation area).

A fundamental approach in the determination of management priorities in the national parks of South Africa is the concept of minimum interference. Minimum interference implies that natural phenomena receive precedence over artificially manipulated options and that managerial measures are implemented to either rectify or pre-empt unnatural disturbances. In this respect, minimum interference may be defined as managerial measures aimed at rectifying (restoring), in the least disturbing manner possible, established and documented deviations in the natural interactions and functioning of the ecosystems as a result of unnatural disturbances and whereby the natural diversity and/or function of the ecosystem is jeopardised.

The Kruger National Park (KNP)

The major attributes of the KNP is its size, its largely pristine ecosystems and the particularly rich structural and species diversity of its biota.

The KNP comprises 1,948,528 hectares and is surpassed in size by only a small number of other national parks and conservation areas. When the area presently comprising the KNP was first proclaimed a conservation area—with the proclamation of the Sabi (1898) and Shingwedzi (1904) game reserves—its ecosystems were largely intact and in their pristine state. This was primarily due to the fact that human settlements were scattered and sparse, and that the area was generally unsuitable for settlement due to the prevalence of diseases which affected man and his livestock (R.G. Bengis personal communication: 1985).

Its particularly rich species diversity may largely be attributed to the fact that the ecological region in which it is located (i.e., the Transvaal Lowveld and adjoining Mozambican plains) fall within the convergence zone of three major ecological regimes, i.e., the mesic, tropical regime from the northeast, an arid sub-tropical regime from the northwest and a mesic temperature regime from the south. Elements representing each of these regimes abound within the confines of the KNP (Van der Schijff 1957, Pienaar 1963a, 1964).

The KNP is elongate in shape, stretching 350 kilometers from north to south and 4,060 kilometers from east to west. In altitude it ranges from 230–750 meters above sea-level and in rainfall from 426–738 millimeters. The topography is largely flat to slightly undulating, and it is fringed by hilly to mountainous terrain only along the southern half of the eastern boundary and in areas along the southern and northern boundaries. Five major perennial rivers, and a short section of a sixth, drain through the KNP from west to east. Other than these rivers, perennial water resources are limited to a few scattered springs and isolated waterholes in the larger seasonal rivers. The area is characterised by two distinct seasons, i.e., the summer season from September to March and during which approximately 80 percent of the rain falls, and a predominantly dry winter season. Summer temperatures range up to 40° Celcius, and more, and only very rarely drop to 0° Celcius or lower during winter.

Available rainfall records indicate a distinct cyclical nature (Gertenbach 1980) and conform to the rainfall patterns of the summer rainfall areas of southern Africa (Tyson and Dyer 1975). In general, climatic cycles consist of a dry and wet phase, each lasting approximately 10 years. The climatic cycle implies that the KNP is subjected to periodic droughts. Together with high prevailing ambient temperatures, all but the most perennial water resources dry up during such dry spells.

Afforestation in the catchments of the perennial rivers, water extraction for urban, industrial, mining and other uses, and silting of the rivers due to poor land management practices have, in recent decades, led to degradation of the rivers and a consequent decline in the quality and quantity of the water. This has had important consequences and has necessitated managerial measures to safeguard the rivers as aquatic ecosystems, in their own right, as refuges for various amphibious mammal populations (e.g., hippo [*Hippopotamus amphibious*]), as suitable habitats for various riverine birds and as water resource for vast numbers of terrestrial animals (Pienaara, 1985).

Despite sections of the southern boundary of the KNP being fenced at earlier stages, a major project was launched in the early 1960s to fence the western boundary. This later led to the fencing of the northern and eastern boundaries, and by 1976 the entire perimeter of the KNP was fenced. In spite of its large size, the area comprising the KNP does not represent a natural ecological unit and with few exceptions the boundaries arbitrarily cut across ecological homogeneous areas. This has had dire consequences for various species. In the southwestern area of the KNP, the western boundary fence severed the migration routes of wildebeest (*Connochaetes taurinus*) and zebra (*Equus burchelli*) and eventually led to the decline of these populations by as much as 95% (Whyte 1985). In other areas animals, e.g., elephant (*Loxodonta africana*) and eland (*Taurotragus oryx*) were cut off from winter and summer dispersion ranges, which necessitated managerial measures to restore stability.

Denying animals the freedom to disperse into areas they would otherwise have occupied under ''natural'' conditions, implies that, left unchecked, their populations would achieve unnaturally high densities. In the case of dominant species, e.g., elephant and buffalo (*syncerus caffer*), their impact on their habitats—and thereby also on associated animal populations— may cause severe degradation before ''natural'' population control measures check population growth. In confined areas, and especially where the preservation of structural and species diversity are of prime importance, it is imperative that managerial steps be taken to maintain some form of ecological equilibrium.

Bush fires have long been recognized as a natural ecological phenomenon. After the long dry winter months when the field layer is mature and dry, when spring and early summer temperatures start to rise prior to the first rains and the prevailing winds are dry and hot, bush fires can range over extensive areas if left unchecked. Once again, due to the confinement of animals by fencing, it has been deemed justifiable that bush fires be kept under control and be applied according to a schedule determined by a concerted research effort.

Policies and Management Strategies

Landscapes and Zonation

In the management of the KNP, it has long been recognized that management priorities were not always equally applicable to the area as a whole but could best be dealt with on a regional basis. Through the years various subdivisions have been suggested, all based on the natural associations of plant and animal communities in relation to distinguishable abiotic features (Van der Schijiff 1957, Pienaar 1963b). Subsequently, and following intensive and extensive phyto-sociological surveys, 35 discrete landscape types have been identified and described (Coetzee 1983, Gertenbach 1983a). As in previous attempts, landscapes were determined on the basis of their ecological uniformity and defined as ". . . areas with a recurrent pattern of plant communities with their associated fauna and abiotic habitat" (Coetzee 1983). Gertenbach (1983a) pointed out that plant communities are not necessarily always recurrent, as suggested by Coetzee (1983), but endorsed the fact that landscapes were characterised by their distinguishable macro-climate, geomorphology, soil and biotic communities. It further pointed out by Coetzee (1983) that landscapes represented distinct ecosystems, within a larger ecosystem. In this respect it was suggested that landscapes ". . . are useful as conservation management units . . . because, within each landscape, the component habitats of plant communities are strongly interdependent and the area occupied by an animal community may include several plant communities. Moreover, in the KNP, natural biological organization at the landscape level in itself forms part of the conservation heritage, to be managed as such" (Coetzee 1983).

In pursuance of its mission to preserve diversity, the various landscapes of the KNP have been accepted as the basic units for determining management priorities and strategies. However, not only ecological issues are at stake in the management of the KNP, but provision also has to be made to accommodate visitors and consequently the provisions of services, infrastructure and facilities. To marry two apparently opposing interests in a system where the primary conservation objectives are met and the essential qualities of a distinctive wilderness atmosphere is preserved together with the aura of tranquillity common to undisturbed natural areas, a system of zonation has been adopted. This system is not unique to the KNP and has, in fact, been adapted to suit the requirements of the KNP from similar approaches taken elsewhere e.g., the U.S. and Canadian national park services.

Despite subtle differences in the various systems, they have all been devised to provide a basic framework within which the essential qualities and intrinsic values of a national park may be protected and perpetuated, and development may take place within specified limits. To meet these demands, zones should provide for the following:

(1) the de-limitation of areas of sufficient size in which the age-old ecological processes may be perpetuated without influence of, and in the absence of any visible impact by modern man;
(2) areas in which the natural features and attributes are of prime importance but where management options may be exercised and where essential facilities (e.g., roads, rest places, etc.) are provided to make the area accessible to visitors; and
(3) areas set aside to provide the facilities and infrastructure necessary to accommodate visitors.

To meet these management expectations, and to ensure success in their practical implementation, three basic zones are acknowledged for the KNP—wilderness, natural, development and general tourism zones.

Wilderness zones. These are areas in which the natural intrinsic attributes are preserved and which are essentially devoid of any visible signs of development by modern man. Wilderness zones are also selected to represent viable units of all the landscapes of the KNP and, as far as possible and as a matter of priority, also include one or more complete drainage systems of which the entire catchment area, drainage lines and watersheds are protected as intact areas free of any developmental programmes.

Natural zones. In these areas, conservation priorities conform to the major ecosystem-orientated objectives, but in which a network of roads, picnic sites and educational centra are provided for the main stream of visitors. These areas could also be considered in the future development of additional facilities.

Development and general tourism zones. These areas are prescribed for the provision of the facilities and infrastructure necessary to accommodate visitors or for the efficient administration of the KNP, and to limit the access of heavy tourist vehicles—which are disruptive to the tranquil atmosphere—to specified routes.

Management Strategies

Management strategies have been developed over many years throughout the developmental history of the KNP. For the purpose of this paper, however, only the very salient factors that played a role in the formulation of a specific strategy, and the approach presently accepted, are outlined. Major contributions toward the formulation of these strategies were made by Pienaar (1969c, (1985), Coetzee (1983), Gertenbach (1983a), (1983b), Joubert 1976, Joubert et al. (1985) and Smuts (1978).

Water provision. In its historical perspective, the provision of artificial watering points was justified as a means of making under-utilized rangelands accessible to herbivores, to counter the loss of traditional watering points through the erection of boundary fences, and to counter the detrimental effects on the aquatic ecosystems of perennial rivers due to disturbances of water quality and quantity from beyond the KNP boundaries.

It is presently accepted that the availability of surface water resources—other than perennial rivers—is primarily dependent on the annual, medium and long term rainfall cycles. Furthermore, due to the fluctuating nature and intensity of rainfall, it is also accepted that surface water resources will fluctuate accordingly and that such fluctuations have played an important role in moulding the intricacies of the KNP ecosystems. However, it is also accepted that the KNP can no longer be regarded as entirely natural due to spatial and other unnatural constraints.

In consideration of these factors, the artificial provision of water is accepted as justified, provided (a) it is in accordance with natural ecosystem principles and (b) full control may be exerted over the resources.

To conform with these objectives, the strategies adopted are that water provision can only be applied to stabilize existing natural resources, and may not be intended to overrule the ecological effects of natural climatic and environmental fluctuations, or to manipulate the density and relative abundance patterns of animal populations.

Due to the desiccation of the perennial rivers weirs may be constructed as a contingency measure to preserve aquatic diversity until such time that a more satisfactory solution may be found. This also applies to catchment dams in seasonal watercourses where aquatic life is spared the detrimental effects of erratic water levels and the effects of pollution.

Strategies related to vegetation. These include veldburning (bush fires), habitat manipulation, the protection of vegetation from over-utilization, the protection of rare plant species and/or communities, and the protection of indigenous flora from invasive alien plants.

1. *Veldburning.* Veldburning has long been one of the major emotive issues in wildlife management. Throughout the years the burning policy has ranged from annual burning to total abstinence from burning. Strong schools of thought supported either of these extremes while others advocated burning at less frequent intervals. None of these approaches was scientifically based and the desire to formulate a fire policy on sound research data served as one of the primary motivators for the institution of a research section in the KNP.

   After considerable research input, it is presently accepted that fires represent a natural phenomenon in the KNP ecosystems, and as such fulfill a role in the complexities of interrelated processes in maintaining the intrinsic values of the ecosystems. However, due to the confined space of the KNP, and particularly the fact that it is entirely fenced, it is considered essential that control be exercised over the extent and frequency of fires, but that such control be exerted in accordance with the basic principles applicable to natural veldfires, i.e., in particular the season (time of the year) in which fires are to be applied and the frequency of such fires—as ascertained from the incidence of lightning induced fires—during the wet and dry phases of the climatic cycle. As presently applied, both the frequency of fires and the season of burning are in accordance with data derived from monitoring the patterns of naturally induced fires. All efforts are also presently underway to incorporate larger units and lightning-induced fires in the burning program.
2. *Habitat manipulation.* Considerable changes, especially in the structure, but in some cases also in the species composition of the vegetation, are associated with changes in the climatic (rainfall) cycle. From existing photographic records and the observations of field staff, it is also apparent that at least some plant communities have shown considerable changes over time. Such changes have inevitably also had an effect on the associated animal populations, and resulted in changes in distribution patterns and relative densities. Research to determine the rate and extent of past vegetation changes and to monitor present trends is presently receiving considerable attention, though much needs to be done before definite conclusions may be drawn.

   Fluctuations in animal populations in response to changes induced upon the vegetation by the climate are also accepted as factors contributing towards the maintenance of the structural and species diversity of the vegetation. These dynamic processes are considered an integral part of ecosystem management.

   Where unnatural disturbances (e.g., boundary fences) exert an influence in either the course or intensity of trend it is considered justified that remedial measures be taken to restore the natural situation.
3. *The protection of rare plant species and plant communities.* The KNP largely falls within the convergence zone of three major ecological regimes. As such, it has a number of plants, or plant communities, which are limited in size due

to the arbitrary nature of the KNP boundaries, or of which the major distribution patterns lie beyond its boundaries. It is, however, accepted that these rare plant species and/or plant communities do not contribute significantly to the functional aspects of the major KNP ecosystems, but are equally deserving of protection and perpetuation as a service to posterity. For the sake of their preservation special protective measures are therefore deemed justified. These measures include devices for the protection of individual plants or the waiving of any of the approved wildlife management programmes, e.g., veldburning, exclusion of animals posing a threat to the vegetation, etc. Management implications of this nature are, however, very limited in the overall management of the KNP.

4. *Invasive alien plants*. In common with a wide range of other aquatic and terrestrial ecosystems, the KNP has had to contend with a growing number of invasive alien plants in its indigenous communities. To counter the spread of such plants within the KNP, the NPB has fully committed itself to participate in any co-operative programmes to identify and eradicate alien invasive plants, especially at their source of origin, to assist in public awareness campaigns against the dangers of such plants, and to continue with its attempts to totally eradicate them within the KNP. In this respect, staff members residing within national parks are also subject to the use of only approved alien plants in their gardens, and encouraged to plant indigenous trees and shrubs.

Animal populations. Policies relating to animal populations involve the management of high and low density herbivores, predators, the reintroduction of locally extinct species and disease control.

1. *High density species*. Under certain environmental conditions, some animal populations have reached peaks which have been considered undesirable and detrimental, to either associated animal species or their habitats. Concern for the extent of damage caused to the habitats and/or the suppression of more sensitive rare species resulted in artificial manipulation (culling) of some of these high density species in the mid-1960s. Species considered to be over-abundant and included in the culling operations were zebra (*Equus burchelli*), blue wildebeest and impala (*Aepyceros melampus*). With a subsequent change in the climatic cycle from a low to high rainfall phase and the associated changes in the environment (habitat), these species, and in particular zebra and blue wildebeest, declined dramatically. Following an intensive research and monitoring program, available data at present indicate that the peaks and troughs in the population fluctuations of these species are largely in harmony with the other components of the ecosystem. It is also acknowledged that, by virtue of their high numbers and their impact on the environment, high density species play an important ecological role in determining the course and intensity of habitat trends, and thereby also exert an important influence on associated animal populations. It is therefore accepted that the difference in relative densities of animal populations in relation to, and in harmony with the environment is an intrinsic attribute of ecosystems.

   A major consideration in evaluating management option in terms of high density species revolves around the spacial limitations of the KNP. In this respect it is current policy that where boundary fences play no role in determining the distribution patterns of species, or influence their movements, and in the case of species that respond to the short term (20-year) climatic cycles, no active involvement in manipulating population trends and densities is deemed necessary. In such cases the population peaks and troughs are left to realize their full potential. It is therefore also accepted that periodic die-offs or periods of sustained heavy utilization are inherent in natural cycles.

In the case of high density species that do not react to short-term climatic cycles, of which the distribution and dispersion patterns are directly influenced by the KNP boundaries and which—by virtue of their size, competitive nature and adaptability—can detrimentally affect associated animal populations and have a dramatic impact on their habitats, would be subject to artificial manipulation. Species in this category include elephant and buffalo. In both cases, it is believed that under more natural conditions they would have dispersed far beyond the boundaries of the KNP. Due to their confinement, it is accepted that their numbers, if left unchanged, would build up to unnaturally high densities and as such their otherwise important contribution towards the maintenance of stable and resilient ecosystems is exceeded and would therefore rather be to the detriment of those ecosystems. In such cases, the NPB has adopted a policy whereby population ceilings have been determined for the species involved and their numbers are regulated on a sustained-yield basis within the ecological carrying capacity of the KNP. In this way healthy and viable populations are guaranteed while their contributions towards the dynamic ecological processes are also secured.

2. *Low density species*. Throughout the years, species which have been sparsely distributed and low in number have generally been considered more vulnerable to population decimating factors than high density species. Data derived from a series of research projects have indicated, however, that the low numbers of such populations may largely be attributed to ecological adaptations, such as social organization and habitat preferences. Mere numbers are, therefore, no criterion by which to judge the stability or resilience of a population. It is therefore accepted that measures to increase the numbers of such populations are not only unnecessary but also undesirable. Should situations arise which could lead to the local extirpation of a low density species, the circumstances are considered on merit and contingency measures may be considered justified to relieve the situation.

Carnivores. In the early years of the KNP, protection of carnivore populations aroused great scientific and public interest. As in the case of veldburning, the question of how to approach carnivores in a conservation context soon erupted in a highly emotive issue. Through the years, management approaches varied from attempts at total extermination to protection in recognition of their role as regulators of the population growth of prey species. The determination to establish the ecological role of especially lion and formalize a policy that would satisfy both scientific and public groups therefore also served as a major motivator for the institution of a research section.

The current approach is that the predator community represents an integral part of the ecosystem and fulfills a vital role in sustaining ecological stability and resilience. It is also acknowledged that predator populations are subject to the same ecological fluctuations applicable to other components of the ecosystem and are, therefore, in dynamic and harmonious balance with them. It is consequently accepted as policy that all predators, with the single exception of lion, are exempted from any form of population control programs. It is, however, further accepted that lions can, in specific situations, cause problems that would not be in the best conservation interest of the KNP and under which it may be advisable to remove a limited number. This option is provided for in the case of species being reintroduced, where it may be necessary to safeguard the new species until it (they) are properly settled.

Reintroduction of locally extinct species. Prior to the conservation effort leading to the proclamation of the KNP, large scale hunting and poaching activities led to the severe decimation of certain animal populations. In a number of cases, e.g., white rhino (*Ceratotherium simum*) and Lichtensteins hartebeest (*Alcelaphus lichtensteinii*), these activities led to the extinction of the populations before effective protective measures could be taken, while others—such as elephant and eland, only just managed to survive. In all cases where authentic records exist of an animal species once having occurred in a particular area, it is policy to consider the reintroduction of the species. The maintenance of fully function ecosystems and the preservation diversity are accepted as fundamental objectives in the reintroduction of species. Important considerations, when reintroductions are contemplated, include the availability of suitable habitat and the release of such animals into the habitats in which they formally occurred. It is also important that ecological equilibria should not be jeopardized by the species to be introduced. Habitat manipulations, or the sustained manipulation of associated animal populations, are not considered justified for the sake of reintroducing a species, especially if populations of that species are adequately protected in other conservation areas.

Disease control. A wide range of parasites, infectious and non-infectious diseases have been identified in wild animals. Highly contagious diseases which may be transmitted to domestic stock, in particular foot-and-mouth disease, have played an important role in the management of the KNP and were, in addition to a number of other considerations, directly responsible for fencing of the western boundary. Most of the diseases transmitted to domestic stock have limited, if any, detrimental effect on the host populations under normal conditions.

As a matter of policy, indigenous parasites and diseases are accepted as an integral part of the biotic communities of ecosystems and their role in sustaining ecological stability and resilience is acknowledged. Diseases known to be of recent occurrence in the KNP (i.e., exotic) are regarded in the same light as any other exotic biota, and continuous efforts are made to eliminate their undesirable effects on the host populations. Furthermore, in the interest of socio economic and zoo-sanitary interests beyond the KNP boundaries, all efforts are made to abide by prescribed procedure to contain and/or combat notifiable (proclaimed) diseases.

Tourism and the principles and policies related to wildlife management. The National Parks Act (1976, as amended) makes provisions for the utilization of national parks for the sustained benefit and enjoyment of the public, while maintaining their natural qualities and their potential to meet the needs and aspirations of future generations.

Various interpretations may be given to the concept of "benefit and enjoyment" of visitors. In the KNP, it has been set as an objective to afford visitors an educational/spiritual experience. To give effect to this approach, it is believed that two essential prerequisites have to be net, i.e., the establishment of an information and interpretive program designed to provide a greater understanding of the concepts of ecosystems, thereby stimulating an awareness and an appreciation for, and a greater sensitivity towards natural ecosystems, and the provision of tourist facilities that are designed to harmonize with their natural surroundings and thereby preserve the wilderness atmosphere.

In accordance with the above guidelines, every effort is made to design visitor facilities in such a way that they blend with their natural environment and that architectural styles conform with the established cultural values for the area. To counter disruptive influence of overcrowding, strict control is exerted over the number of overnight and day visitors. Control measures are also aimed at regulating vehicular travel to avoid heavy traffic and/or congestion on the roads (Joubert et al. 1985).

It is a consideration of the highest priority to make the KNP accessible and affordable to the widest possible spectrum of visitors. In this respect it is imperative that price and tarriff structures are not prohibitive to middle and lower income groups. This is achieved by providing a wide range of facilities to cater for all income groups and to meet the expectations of a wide range of interest groups. Facilities range from rustic A-frame bush camps from where guided hiking trails are arranged, to camping/caravan parks, furnished tents, traditional rondavel-type units with or without amenities, and family and guest cottages. Larger rest camps, accommodating from 400–600 people, are furnished with restaurants, shops, cafeterias and petrol stations. A number of smaller rest camps have also been erected, but without these facilities, to maximize the wilderness experience. In addition, a number of so-called private rest camps have also been established, accommodating between 12 and 18 people and are rented as a single facility. The extensive network of surfaced and gravelled roads provide opportunities for visitors to travel either in their private vehicles, in rented vehicles or coaches organized by travel agencies. Two commercial airlines operate daily into Skukuza, the headquarters of the KNP.

Research and Administration. To address the various wildlife issues and formulate policies, a research section was instituted in 1951. Though the initial motivation for the research section revolved around the solving of a number of emotive issues at the time, it soon expanded its responsibility to encompass all wildlife management issues. In addition to inventorizing all the components comprising the ecosystem, the main thrust of research focused on a comprehensive monitoring system to identify and analyse cause and effect relationships. In this respect the major research objective for the KNP has been defined as:

"A study and analysis of the ecosystem, with detail consideration of the dynamic nature and interdependency of the individual components comprising the system, with a view to interpreting and predicting changes within the system and therefore also to serve as basis for the implementation (and evaluation) of management strategies as necessitated by circumstances" (Joubert 1975).

The analysis and interpretation of research results, and the formulation of management strategies are undertaken by the Standing Committee for Wildlife Management. This Committee is represented by the two most senior officers from each of the Research and Wildlife Management Section, under the chairmanship of the Park Warden.

The overall administration of the KNP is represented by five divisions, i.e., Research and Environmental Communication, Wildlife Management, Tourism and Trade, Technical Services, and Administration. For the integration of wildlife management interests with the developments such as road infrastructure, rest camps, administration complexes and living quarters, the KNP Management Committee—with representation by all five divisions—meets at regular intervals— also under the chairmanship of the Park Warden.

Conclusions

The management of the KNP is based on the internationally accepted norms and principles applicable to national parks. While every possible avenue is pursued to retain its ecosystems in their pristine state, it is also accepted that intervention is justified under specified circumstances. Where such intervention is required, management strategies are formulated on the basis of an extensive and intensive research and monitoring program. The provision of infrastructures and facilities to accommodate visitors, and the control exerted over the number of tourists allowed into the KNP at any one time, are designed to blend with the wildlife policies and to afford visitors the maximum benefit of a wilderness experience, and the peace and tranquility that goes with it.

The KNP is not only the flagship of the South African national parks, but is also deserving of the status of an international park.

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Wildlife Conservation in Central America: Will It Survive the '90s?

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Introduction

Central America—composed of Belize, Guatemala, Honduras, El Salvador, Nicaragua Costa Rica and Panama—is exceedingly complex geographically, featuring active volcanoes, rift lakes, freshwater and coastal wetlands, cordierras that rise to alpine paramo, semideserts, rainforests, and a world class barrier reef system. The uniqueness and unusually diverse biota of the Mesoamerican isthmus can be attributed to this medley of habitats and to its location at the juncture of two biogeographical provinces that bridges two great continents and separates the two largest oceans in the world. (Budowsky 1977).

Although basic inventory work is incomplete in all countries, initial surveys highlight the biological wealth of the region. Some 22 life zones, harboring more than 15,000 plant and 2,100 nonmarine vertebrate species, have been identified (B. Stein personal communication: 1991). Costa Rica, best known for its high conservation profile and attractiveness to foreign investigators for many decades, has established a Biodiversity Institute to catalogue the nation's biota (Janzen 1989, Vaughan 1990). Incipient efforts in Guatemala may result in it being recognized as the most biologically diverse. Already, approximately 1,600 species have been listed, including 258 freshwater fishes, 112 amphibians, 214 reptiles, 738 birds and 251 species of mammals (J. Vaninni personal communication: 1990). Costa Rica and Guatemala are thought to support the most diversified plant growth in the region, though definitive sources to verify these assertions are not present (Leonard 1987). Costs Rica may hold over 2,000 species of broadleaf trees and over 12,000 species of plants, while Guatemala's forests contain 16 species of conifers.

Central America's impressive array of fauna, flora and natural habitats is threatened by a variety of forces, not unlike those elsewhere in the neotropics. Nowhere, however, are these pressures concentrated in such a small area. Political and military violence, external debt crises, development policies, social and economic inequities, and human demographics are collectively forcing profound transformation of these unique environments (Nations and Leonard 1986, Leonard 1987, Karliner 1989 Vaughan 1990). Complex forest habitats are being converted to simple, degraded ecosystems, soils are eroding and being poisoned by inappropriate agricultural technologies, waterways are being polluted by chemical and organic effluent, and individual ecosystem components are being unsustainably exploited (Leonard 1987, Karliner 1989). Central America is fast approaching a critical stage in its ecological destabilization. If allowed to continue along its current course, the natural resource base required for sustainable economic development, social and political stability, and maintenance of the ecological integrity and diversity of the region will be lost, perhaps irretrievably so.

Wildlife Conservation Profile

Developing a wildlife conservation strategy in Central America requires not only that the underlying causes of the challenge are clearly understood, but that immediate constraints are recognized and addressed. Numerous obstacles to implementing an action plan have been identified and discussed in several Central American natural resource fora (MacFarland et al. 1978, Ponciano 1987). Over the past five years, meaningful action to solve them has been occurring.

Wildlife Conservation Mission

Central American wildlife management authorities are challenged by a complex and, at times, potentially contradictory mission. while they are tasked to maximize for genetic and ecosystem diversity and sustainability, and to promote public awareness of wildlife concerns, they must also engage in complimentary efforts to satisfy basic human needs and to meet national economic development goals (Ponciano 1987, Morales and Cifuentes 1990). Frequently, this latter goal is overly simplified to the degree that wildlife management becomes synonymous with production of bush meat for the rural poor (Thelen 1990). How this objective is balanced with responsibilities relating to biodiversity conservation is an ongoing challenge and has not been well articulated in the literature.

Legislative Reform

Legislation that effectively addresses the multiple threats to wildlife and supports management policy reform is needed in most countries. Only Costa Rica and Guatemala have omnibus wildlife laws that deal with protection, use and management. Wildlife issues are regulated by basic hunting laws in Nicaragua and Panama. Honduras and El Salvador have no specific wildlife legislation, save administrative decrees on harvest quotas. Honduras, Guatemala and Belize have placed temporary moratoriums on wildlife utilization pending status surveys of commercially important species. With El Salvador's accession in 1987, all Central American countries are now signatories to the Convention on International Trade in Endangered Species.

Law Enforcement

Though the principle responsibility of most wildlife agencies is regulatory in nature, enforcement of national wildlife legislation and compliance with international conventions has been uneven (Barborak et al. 1983). Until it halted wildlife export in January 1990, Honduras was a center of large-scale commercial wildlife traffic under a self-policing quota system that was both vague and corrupt (Cruz 1989). Between April 1987 and May 1988, over 225,000 reptiles and amphibians, 18,000 birds—mostly psittacids, and 778 mammals were ''legally'' exported from the country, though such numbers were far in excess of the export quotas (Midence 1990). Until 1990, Nicaragua officially sanctioned wildlife commerce as a priority activity of the management. though concern was given to regulation of the movement of wildlife and wildlife products once they were removed from the wild, scant attention was allotted to the sustainability of such harvest levels. Wildlife trade has declined in recent years, but is certain to rebound as the export moratoria expire or pressure mounts to rescind them. Central America's past high profile in intraregional and international wildlife commerce clearly justifies establishing an independent trade monitoring office.

Institutional Framework

In addition to a weak legislative footing, the effectiveness of wildlife agencies is compromised by a high turnover in leadership, lack of trained staff and paltry operational budgets. All reflect the relatively low political status given wildlife management.

The creation of administrative authorities to manage and protect wildlife in Central America is a relatively recent phenomenon. With the exception of Nicaragua, which established a small department in the mid 1950s, no country recognized the need to specifically address wildlife conservation until the early 1970s. Most have been very unstable since their creation. Costa Rica and Nicaragua have each restructured their wildlife agencies six times, and all but El Salvador have reorganized at least once in the past three years.

Low pay and marginal political influence of the agency has discouraged leadership in wildlife conservation. Of 17 representatives of Central American government and non-government institutions attending the first Central American Wildlife Meeting in 1978 in Managua, Nicaragua, 10 years later, 2 were in the original position, 2 remained in the same institution but occupied a different position and five, though still involved in wildlife conservation, were in different institutions. Nearly half were no longer working in the conservation field. Since 1980, every Central American wildlife agency has changed directors on at least three occasions.

Wildlife agency budgets are consumed almost entirely by salaries and are woefully inadequate to meet even the most basic operational needs. Office supplies, fuel for vehicles, field supplies and equipment are rarely available. Most agencies depend on international support to maintain a regular presence in the field.

All management authorities lack the cadre of well trained and field tested personnel necessary to implement regulatory, research and management action. No Central American wildlife management agency has more than six full-time biologists on staff and in nearly all cases, formal training has been in traditional basic science programs that lack an applied orientation. In service training for paraprofessionals and upgrading of undergraduate programs in natural resource management is needed throughout the region and improvements are being made. With the exception of Belize, all countries have university undergraduate programs in biology, ecology and/or natural resources management. Several institutions, particularly the University of San Carlos, Guatemala, the University of El Salvador, and the Central American University, Nicaragua, are in various phases of restructuring their programs to make them more responsive to the socio-economic realities of natural resource management in their countries.

The Wildlife Management Program at the National University in Costa Rica has created professional training opportunities and since 1987 has trained nearly two dozen master's students (Vaughan 1990). In addition, several international training organizations including the Smithsonian Institution, the University for Peace and the Center for Tropical Agricultural Research and Training (CATIE) have been providing short course instruction in wildlands planning and management, but the need for additional short term training for paraprofessionals is far in excess of the current institutional capabilities to meet it.

Privatization of Conservation

All governments are currently looking to the private sector for solutions to the critical economic and social ills besetting their countries. This new perception of the limits to government responsibility for the common good is spilling over to environmental issues and may affect wildlife conservation. In the ever increasing need to cut public sector spending, governments are looking to non-governmental organizations (NGO) to take on direct management of national parks and reserves.

In Honduras, Belize, Guatemala, Panama and Costa Rica, the private sector's role in protected areas management is firmly established and increasing. In several cases, national NGOs have a long history of acting as surrogates for the state in management of parks and wildlife. The Belize Audubon Society (BAS) has administered the public protected areas system since 1981. All park guards are BAS personnel and the government overall has had a minimal role in park and wildlife management. In Panama, the National Conservation Association (ANCON) has provided technical and financial assistance to the natural resource institute, INRENARE, and efficiently and effectively carries out joint management of the parks through a cooperative agreement. Because ANCON has control of the international funds that form the bulk of the operational budget, and in some cases pays park guards, the role of INRENARE has been marginalized to the point where their administrative authority is in question. Consolidation of private sector's management of public areas in Guatemala began in 1990 when the NGO, Defenders of Nature, was assigned management of the Sierra de las Minas Biosphere Reserve. Four other private organizations are being encouraged by the government to take on fund raising and management responsibility for individual units of the protected areas system. In Honduras, the Cuero y Salado Foundation has been given legal authority to manage a national wildlife refuge. The Honduran Ecological Association recently agreed to become official administrator of La Tigra National Park, the keystone unit in the country's protected areas system.

The appropriateness of privatization of protected areas management is being actively debated in Central American conservation circles (A. Ugalde personal communication:1991). Few alternatives are apparent to relieve the public sector of some of the management burden and costs and several advantages are evident. First, the private sector is better positioned to develop and manage innovative funding mechanisms. Secondly, NGOs often can respond more quickly to the dynamic needs of conservation. The question of how the NGOs will handle law enforcement and balance the potential conflicts of interest is troublesome. National parks, and the wildlife they harbor, form part of each nation's natural heritage to be managed for the public good. The actions of a private organization may come in conflict with the common interests of the whole society, and, perhaps, even jeopardize the natural integrity of the ecosystem under its care if policy and regulatory oversight by a state agency responsible to the citizenry is lacking. This would be of special concern if the park is a composite of public land and holdings of the private organization entrusted with management of the entire area.

Scientific Basis of Protected Areas Systems

Many parks and reserves in Central America have been established in an *ad hoc* manner to preserve critical habitats before they were degraded by imminent commercial development and colonization. As such, there was generally little opportunity to determine the ecological representativeness of the sites, study the current and future threats to the biota or provide basic biophysical and socioeconomic information essential for proper zoning for public use.

The Costa Rican protected areas system, certainly the most advanced and well managed in the region, includes 58 units, which are distributed in 12 forest reserves, 30 wildlife refuges, watershed protection zones, and biological reserves, 14 national parks, and 1 absolute nature reserve (Ramirez and Maldonado 1988). Nevertheless, much of the country's natural heritage is not found in the system. Of the 53 major vegetation types recognized in the country (Gomez and Herrera 1986), only 36 are represented in units of strict protection (Alfaro 1988). Thirty-four of 45 woody species threatened with extinction, and 8 of 9 endemic species are represented in fewer than four units. Nearly 10 percent of all mammal species and 16 percent of the 45 threatened species are unrepresented. Another 39 percent of the total, and 37 percent of those in the threatened category are found in only one or two units. Of the 170 species of endangered birds, 7 percent are not represented in protected areas, and another 44 percent are only found in one or two units. Despite reasonably good protection programs, clearly marked boundaries and sophisticated public awareness of the system, 14% of the units are regularly perturbed by illegal hunting and habitat alteration (Ramirez and Maldonado 1988). The expectation that the Costa Rican protected areas system is adequate to preserve the nation's wildlife is further weakened by concern that the majority of the individual units probably are too small to maintain long-term genetic diversity.

Parks managers and systems planners cannot be expected to efficiently and effectively meet long-term biodiversity conservation objectives nor provide safeguards for planned utilization of wildlife resources without baseline inventory information (Thorsell 1990). Biological data must be closely merged with socio-economic assessments, since many of the threats to wildlife relate to utilization, and many protected areas are designed to permit some level of resource use by local communities. Evaluation of population status of economically and educationally important species, current utilization levels, and tourism carrying capacity are priority topics. The information generated from such studies should be reported promptly and in a format and language that is accessible to the managers.

Administrative Restructuring

Several favorable changes are afoot. First, over the past five years, several countries have made policy statements and effected administrative modifications that further serve the conservation of biodiversity. These changes are expected to increase participation of resource managers in national economic policy-making processes. For example, all countries have combined protected areas and wildlife management administration. Most have also relocated the agencies from agriculture ministries, with their traditional emphasis on production, to semi-autonomous institutes (Panama, Nicaragua, Guatemala, Honduras) or to natural resource ministries (Costa Rica and Belize). Only El Salvador retains its parks and wildlife agency under the jurisdiction of the Agriculture ministry. In Honduras, responsibility for protected areas and wildlife was removed from the ineffective Renewable Natural Resource Agency in 1991 and assigned to the more professional and semi-autonomous State Forestry Corporation. This is expected to have duel benefit of strengthening the wildlife agency and eliminating overlapping authority that previously existed between the two entities. Nicaragua has embarked on an ambitious plan to restructure its natural resource management authority, IRENA, along the lines of a superagency for the environment (Gutierrez 1990). Belize created a Conservation Division in 1990 that will eventually reassume policy making and management responsibilities for a protected areas system, which is expected to expand significantly during the next several years. El Salvador has included two articles in its new constitution mandating natural resource conservation, and Costa Rica's president, Rafael Calderon, has declared that a new "ecological order" will guide his administration's economic decision making.

Participatory Decision Making

A more participatory procedure for policy and management decision making is gaining favor. It is especially well developed in Guatemala where the statutory authority for the protected areas system is an independent interinstitutional presidential advisory council composed of representatives from public and private sectors. In Belize, an environmental advisory council was established in 1988 to assist government in developing natural resource policies. In Nicaragua, an interinstitutional commission on environment and land use, CONAMOR, was established in 1990 that includes representation from eight government ministries and institutes and the private sector. Presided over by IRENA, but housed in the economics ministry, it will advise the executive branch on environment and economic development policy, priorities for foreign aid assistance, and developing funding programs for debt for nature conversions (Gutierrez 1990).

Decentralization of Management

Several countries are experimenting with a decentralized protected areas administration with the expectation that management efficiency and local response to resource conservation needs will follow. This is most advanced in Costa Rica, where the protected areas system has been reorganized into seven regional conservation areas or "megaparks" that integrate the conservation needs of multiple units with local development priorities (Vaughan 1990). Others, such as Honduras and Guatemala, are decentralizing park administration through legal empowerment of NGOs to manage land and wildlife.

Regional Communication and Cooperation

Intraregional communication and coordination has improved with the establishment of the Central American Commission on Environment and Development, an outgrowth of the Central American President's Esquipulas peace initiative. Ministers of natural resources meet regularly to discuss environment and development issues that are a regional nature and whose influence cross national boundaries. For example, they recently declared the region as a toxic waste-free zone to forestall it from becoming a dumping ground for developed nations, and have discussed intraregional wildlife traffic and border peace parks.

Protected Area Systems

Massive loss of productive ecosystems in Central America has not been ignored. Pressured by remarkably diverse community of over 60 conservation NGOs, all countries have recognized the importance of safeguarding a portion of their rich natural heritage. Wildlife conservation efforts in Central America have focused principally on protection of populations located in gazetted parks and reserves, and in regulation of wildlife use elsewhere.

Officially gazetted protected areas have increased from 30 in 1970 to more than 230 by 1990 (Table 1). Only 30 percent are categorized as national parks or other strict protection units, while the remaining are designed to permit some consumptive utilization of resources by the citizenry. The units range in size from only a few dozen acres for some of Guatemala's anthropological sites, to the 840,000 acres (350,000 ha) Rio Platano, 1.2 million acres (500,000 ha) Darien and 3.6 million acres (1.5 million ha) Maya biosphere reserves in Honduras, Panama and Guatemala, respectively. Collectively they cover over 29,000 square miles (77,000 km), potentially archiving nearly 15 percent of the region for present and future social, economic and ecological needs. Indigenous reserves add significantly to this total in Panama and Costa Rica. Another 130 sites have been identified as potential protected areas. Despite the advanced development of a protected areas system in Central America, few of the region's wildland units are unthreatened and many have lost the natural and aesthetic resources for which they were created to preserve.

Clearly, efforts at conserving wildlife cannot be exclusively directed at national parks since the majority of the forested land and wetlands in Central America remain outside protected area systems. The value of privately held forests as biodiversity refuges is being recognized. Costa Rica acknowledges private wildlands that are managed for conservation purposes as a complementary subset to the national pro-

Table 1. Protected Area Systems in Central America.[a]

IUCN Management Categories	Countries							
	BZ	ES	GU	HO	NI	CR	PA	Total
Natural reserve						1		1
National Park	2	4	20	12	3	14	11	66
Natural Monument	1			1	1			3
Biological Reserve	5	2	7	28	3	30	2	77
Cultural Monument	1		23	1	1	1		27
Interim Reserve					11			11
Forest Reserve	15		3	5		12	10	45
Biosphere Reserve			2[b]	1		2[c]	1[c]	2
Total public units	24	6	54	48	19	58	23	232
Area public units								
Square miles (× 1000)	2.9	0.08	7.0	3.2	1.8	5.1	9.6	29.8
Km^2 (× 1000)	7.6	0.2	18.2	8.3	4.7	13.3	24.8	77.1
Percentage total territory	33	1	17	7	3	26	32	15
Total other wildlands:								
Private reserves	3					5		8
Indigenous reserves	6					6	3	15
Potential new reserves	29	22	19	10	18		32	130

[a]Compiled from: Boyer (1980), CENREN (1987), Hartshorn et al. (1984), Hartshorn (1983), Gutierrez (1990), Leonard (1987), Miller (1991), Morales and Cifuentes (1989), and Ramirez and Maldonado (1988).
[b]One unique management unit.
[c]Composed of management units included elsewhere.

tected areas system and has added five such sites ranging in size from 480–12,000 acres (200–5,000 ha) Management authorities for these areas include universities, regional training centers, research organizations, tourism operators, conservation organizations and private individuals. El Salvador has embarked on a novel plan to entrust municipalities and agricultural cooperatives with direct management of new parks and reserves being established in collaboration with the agrarian reform program (CENREN 1987).

The value of tropical agroecosystems to wildlife conservation has been largely ignored. In Guatemala, many coffee, cardomom and macadamia plantations are particularly important because they are managed under native shade for low input and low human traffic. Furthermore, they occupy an elevational range that is practically unrepresented in the protected areas system. Under sensitive, informed management, these areas become exceedingly important as buffer zones for officially gazetted national parks. They are contiguous to the plantations and provide critical habitat for species that must make altitudinal migrations during the year (J. Vannini personal communication: 1990).

Conclusion

The establishment of private reserves to complement publicly held wildlands, and innovative "re-texturing" of economically important habitats for successful coexistence between man and wildlife will be essential to conserve the region's biodiversity. However, the dramatic and continuing transformation of the landscape in Central America makes clear the undisputed importance of a regional system of properly managed national parks, reserves and refuges if the region hopes to enter the 21st century with a semblance of its extant wildlife resource ecologically and genetically intact. Creation of biological corridors to connect parks and reserves, changes of management category to provide more strict protection, and integrating better resource management of park land's area of influence will be essential to meet this goal.

Linked to this effort must come a broad commitment to reorder national development priorities and make them environmentally sensitive. Natural resource conservation and rural development organizations, at both the regional and international levels, must join forces if either conservation or development can expect to be successful in the long term. Extraction of timber and non-timber products, ecotourism, agroforestry, wildlife ranching, and low input agriculture are commonly promoted as appropriate buffer zone activities under the label of sustainable development. Generally, however, practice is far behind the rhetoric, particularly as it relates to wildlife conservation. The oft cited examples of sustainable utilization of wildlife in Latin America (FAO 1985, Heckadon et al. 1990, Vaughan 1990), remain largely research and development experiments. None can be termed "model" projects since they have not progressed to a broad extension phase. One of the objectives of Central American wildlife conservation in the 1990s must be to objectively evaluate the current methodologies and technologies of sustained development in and around protected areas, evaluate new approaches, and work towards insuring their wide application, for wildlife and wildland conservation purposes, where appropriate.

I share the optimism of Vaughan (1990) that wildlife can survive in Central America. However, it will require a herculean effort similar to what Robinson (1988) has labeled the environmental equivalent of a Manhattan Project or what J. Incer (personal communication:1990) has called an Ecological Marshall Plan. It will necessitate a reordering of economic policy in Central American and foreign policy in the developed world. It must also be accompanied by commitments of funding and technical assistance that far surpass what has been available thus far from international conservation organizations and bilateral aid agencies. The effort should integrate research, education and on-the-ground pilot management projects with concurrent efforts to fundamentally change current policies that often ignore the importance of biodiversity conservation and potential economic value of wildlife. Importantly, grassroots development organizations must be recruited to the effort so that their expertise in community empowerment can be joined. Improving the quality of life of Central Americans and assuring the survival of the region's wildlife are mutually interdependent.

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Disease Management in Wood Buffalo National Park, Canada: Public Attitudes and Management Implications

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Athabasca

Introduction

In February 1989, a Panel was appointed under the federal Environmental Assessment Review Process guidelines to examine the problems raised by the presence of tuberculosis and brucellosis in the bison (*Bison bison*) inhabiting Wood Buffalo National Park (WBNP) and surrounding areas. The Panel reported in August 1990 (Connelly et al. 1990). Its major conclusions were: (1) that the presence of the diseases constitutes a small, but finite risk to other bison in the region, to cattle, to other wildlife and to people; (2) that fences and buffer zones, while useful as interim measures, are fallible in the long term; (3) that there is no treatment for the diseases in wild animals; (4) that vaccination has not proved effective in the past; and (5) that test and slaughter is only feasible for small groups of animals because of the prevalence of false negative tests. The Panel recommended that the only practical solution to the disease problem was elimination of all disease-exposed individuals with replacement by disease-free individuals. The Panel also recommended that replacement stock be of the wood bison (*B. b. athabascae*) phenotype, which can be obtained from Elk Island National Park (EINP), and from limited salvage during depopulation of WBNP.

Origin of the Problem

In February 1907, the government of Canada entered into an agreement to purchase 150 plains bison (*B. b. bison*) from Michel Pablo, a rancher, of Missoula, Montana. The agreement was later amended to include Pablo's entire herd. From 1907 to 1912, 716 bison were delivered to the rail head at Ravalli, Montana, for transshipment to the newly established Buffalo National Park near Wainwright, Alberta. The herd numbered about 1,000 in 1912, passed 2,000 in 1916, and 5,000 in 1921, by which time the available range was under severe stress. (*see* Lowthian (1981).

In 1923, 265 "old males" were culled and examined for parasites and diseases. A veterinarian (Cameron 1923), mentioned the presence of bovine tuberculosis (*Mycobacterium bovis*) but did not reveal the prevalence. Not until 1942, did the public learn that 76 percent of those examined were infected (Hadwen 1942). Hadwen also described symptoms consistent with a diagnosis of brucellosis (*Brucella abortus*), but he did not list brucellosis among the diseases identified.

Wood Buffalo National Park (WBNP) was established in 1922, primarily to protect an estimated 1,500 wood bison. Nothing is known of their disease status.

In 1925, the government of Canada began to transfer plains bison from the overstocked range at Wainwright to WBNP, although scientists in Canada, and elsewhere, protested that the transfer would result in introduction of diseases, primarily tuberculosis, and loss, through hybridization, of wood bison as a subspecies (Lowthian 1981). By 1928, 6,673 plains bison had been shipped from Wainwright, but an unknown number failed to survive the journey.

Contact between wood and plains bison was observed by the Buffalo Rangers almost immediately (Mike Dempsey personal communication) Interbreeding followed. Tuberculosis was diagnosed in a single individual in 1946. Brucellosis was diagnosed from positive serum tests in 1956. Both diseases have been found in every sample examined since. Thus, the problems foreseen by the protesters are with us to this day.

Bison Numbers in Wood Buffalo National Park

Bison numbers increased to around 12,000 by 1949 (Fuller 1950) and stayed at about that level until 1970 when they went into an exponential decline ($r = -0.05$) (Messier 1989) that has lasted to the present. A population near Hook Lake, northeast of the park, declined even faster ($r = -0.19$) (Messier 1989). In March 1990, the population was estimated to be 3,200 in the Park and less than 4,000 overall. Factors involved in the decline are: a loss estimated at 3,000 from drowning in a flood in 1974; losses from several outbreaks of anthrax; loss of winter habitat due to vegetation changes in the Peace-Athabasca Delta; loss of suitable range due to extensive forest fires; presumed increase in calf mortality from wolf predation; some mortality and some decreased natality from tuberculosis and brucellosis.

One additional factor to be taken into consideration is the gradual approach of agriculture to the southwestern corner of WBNP. Not only do local farmers raise cattle (and in one case, plains bison), but a grazing range near Fort Vermillion has catered to cattle from as far away as central Alberta. At least two herds of bison occur between the park boundary and the outermost farms, and bison have been seen in and around farmyards, hence, the perceived threat to agriculture.

Rediscovery of Wood Bison

In the early 1960s, about 200 individual animals that appeared to be of the wood bison phenotype (Banfield and Novakowski 1960) were captured near the Nyarling River in the northwestern part of WBNP. They were held in corrals and tested for brucellosis and tuberculosis. Some infected animals were identified and slaughtered; the remaining, presumed-healthy animals were used to start new herds in the Mackenzie Bison Sanctuary (MBS), northwest of WBNP, and in EINP near Edmonton.

Limited sampling in the MBS has revealed no infected individuals and the herd is considered to be disease-free. Its numbers increased exponentially ($r = 0.232$) for the first 16 years to 686 in 1979 (Fuller and Hubert 1981), and thereafter doubled once more to about 1,600 before growth slowed. In 1990, it numbered just over 2,000 individuals. Bison in the MBS are not isolated by impenetrable barriers from those in WBNP.

Disease resurfaced at EINP but was eliminated by a rigorous test-and-slaughter regime. Numbers are now maintained at around 400 individuals and surpluses have been used to found new herds.

Wood Bison Recovery Plan

A team, made up of representatives of federal, provincial and territorial wildlife officials, and World Wildlife Fund (Canada), has developed a plan to remove wood bison from the list of endangered species. Their objective is to establish at least four free-ranging herds, each having a population of at least 200 individuals. Only the MBS herd meets the criterion so far, although herds established in the Nisling River region, Yukon, and the Nahanni region of the Northwest Territories probably each exceed 100 individuals. A fourth group is awaiting release in northwestern Alberta. Its fate is in limbo pending resolution of the disease problem in WBNP. The presence of tuberculosis and brucellosis in WBNP removes from consideration for restocking a major part of the available range of the subspecies and may jeopardize the whole recovery plan.

Response to Panel's Recommendations

As might be expected, the response has been divided. The Wood Bison Recovery Team and its sponsors, and many academics have been in agreement. So has the livestock industry. On the other hand, some academics, several conservation organizations, aboriginal populations in the vicinity of WBNP and Parks Canada have taken a negative stance. Their objections fall into six major categories.

The Current Prevalence of Disease

Most of the existing data were gathered between 1950 and 1974. Seven slaughters on prairies (Hay Camp) and six slaughters on the Peace Delta (Sweetgrass) revealed lesions typical of tuberculosis in 37.3 percent ($n = 1{,}982$) and 31.6 percent ($n = 1{,}059$), respectively, of the animals autopsied. The G-test for independence gave high values (55.0 and 49.2) with associated probabilities much less than 0.001. Overall, the prevalence at Hay Camp was higher than that at Sweetgrass (pooled $G = 9.90$, 1 df, $p < 0.005$). No trend is apparent in the data. Much the same applies to the prevalence of brucellosis, which had a 39.5 percent prevalence ($n = 1{,}681$) at Sweetgrass and G for independence among seven samples was 81.5. Again, there was no trend.

Between 1983 and 1985, Tessaro (1990) examined 72 bison of which 21 percent were infected with tuberculosis and 25 percent were infected with brucellosis. Both percentages are within the range of the early data. More recent still is a finding of brucellosis in 80 percent of 58 animals sampled in August, 1990 Curtis Strobeck (*personal communication*: 1991).

Although a number of intervenors argued that new data were required on the current prevalence of the diseases, the Panel disagreed for several reasons. Prevalence rate is only one of a number of factors that determine the risk of transfer to other species. Chronic diseases, with a long infectious period, are unlikely to disappear spontaneously from a social species. The wide variation in prevalence from place to place and year to year, and the absence of any trend suggest that further sampling would be unlikely to yield significant new information.

Status of Wood Bison

Validity of the subspecies *B. b. athabascae* has been questioned from time to time, since it was described (Rhoads 1897). If the designation is invalid, there is no need either to salvage, or to restock with, the wood bison phenotype. Even if one accepts the validity of the subspecies, one may question whether the animals salvaged from the Nyarling River area are wood bison after 30 or so years of potential contact with introduced plains bison.

Phenotypic differences between plains bison and Nyarling River animals in EINP were described by Geist and Karsten (1977). The numerical taxonomic study of van Zyll de Jong (1986) supported the subspecies concept and recognized Nyarling River animals as wood bison, although admitting an introgression of perhaps 5 percent of plains bison genes. Molecular genetic studies of Bork et al. (1991) demonstrate sufficient difference to warrant maintaining descendants of the Nyarling River animals as a separate population.

Salvage of Additional Genetic Material

The number of founders that actually contributed genes to the existing populations of wood bison is not known precisely. It was about 40. Some groups argued that as many healthy animals as possible ought to be saved, regardless of phenotype, in order to broaden the genetic base of future populations in WBNP and elsewhere. The Panel found records of 18 herds, with number of founders ranging from 5 to 57, and for only 1 of them ($N_e = 5.33$) was there any suggestion of negative inbreeding effects. Furthermore, the rapid recovery of the MBS herd from a severe bottleneck ($N_e = 16$) and the healthy condition of the EINP herd suggest that there is no necessity to broaden the base, although it may well be desirable to do so.

A serious problem with extensive salvage arises from the inefficiency of the skin test to identify bison infected with tuberculosis. Only about 16 percent of 4,495 animals tested reacted positively whereas, as noted above, more than 30 percent showed lesions. False negative tests for brucellosis also occur. If infected individuals are returned to the population after each test, the chance of eliminating the diseases is vanishingly small, but if small groups are held in separate facilities, at least some of the groups may be "cleaned up" and available for restocking.

Aboriginal Concerns

Bison play both a utilitarian and a spiritual role in the life of the aboriginal peoples living in and around WBNP. They have the right to hunt the existing bison, which are considered to be hybrids, for food at any time of the year outside the park. Wood bison, however, are on the protected list in both Alberta and the Northwest Territories. The Panel has recommended, therefore, that as soon as the numbers warrant, the right to hunt wood bison, guaranteed in the treaty signed in 1898, must be returned to the native people. Native spokesmen were not at all impressed by the concept of subspecies.

Native hunters also find it difficult to believe that animals that look healthy could in fact be infected. They therefore questioned the prevalence rates. Emaciation is obvious in late stages of tuberculosis; a lesion in a retropharyngeal lymph node is not. Arthritis and orchitis are concomitants of brucellosis, but most infected individuals show no outward signs.

Concern was also expressed that the government might run out of money once the depopulation was complete and the repopulation might never occur. That, of course, would open the way to doing away with WBNP and committing the land to either agriculture or forestry. To counteract that concern, the Panel recommended that no depopulation commence before facilities for breeding replacement animals are in place and stocked. It was further recommended that the facilities be managed by aboriginal groups, and turned over to them once repopulation has been accomplished.

Heritage Values

WBNP is a UNESCO World Heritage site. The designation was based, in part, on the presence of the world's largest herd of free-roaming and self-regulating bison. However, UNESCO recognized that some form of intervention might be required because of the presence of infectious diseases. The park is also a large protected ecosystem, and it contains a part of the largest fresh-water delta in the world—the combined deltas of the Peace and Athabasca Rivers. The delta, and the only known nesting ground of whooping cranes (*Grus americana*), have been designated wetlands of international significance under the Ramsar Convention. Without doubt, temporary elimination of bison will interfere with normal ecosystem functioning. In particular, predator/prey relations will be disrupted and lack of grazing may result in changes to plant communities.

However, it is necessary to point out that the park's status as a protected, wilderness ecosystem has already been compromised in several ways. Eligible persons may hunt and trap birds and mammals, except bison, and harvest fruits. White spruce (*Picea glauca*) has been logged for half a century and will be logged until 2002. Commercial fishing was conducted in Lake Claire in the early 1950s. The Peace River portion of the delta has changed markedly since the Bennett Dam virtually eliminated spring floods.

Several important questions can only be answered qualitatively, on the basis of value judgements. Is the existing mixed population of greater heritage value than a reconstituted population of animals resembling as closely as possible the endemic race? The Panel thought not. Is a diseased population as valuable as, or more valuable than, a reconstituted healthy one? The panel thought not. Are the disease organisms themselves part of the heritage of the park? Because they were probably not endemic, the Panel thought not.

External Forces Influencing Parks Policy

Some groups felt that agricultural interests were forcing the agenda, which, if true, could set a dangerous precedent for future management and protection of National Parks. The Panel's first concern, however, is the disease-free bison in the MBS.

Political Response

The federal government accepted the Panel's report and gave it a qualified approval-in-principle in August 1990. At the time of writing this paper (early February 1991), no concrete action had been taken to further the proposal.

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Ecological Justification for Controlling Deer Populations in Eastern National Parks

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Introduction

Should white-tailed deer (*Odocoileus virginianus*) populations in National Park Service (NPS) areas be controlled by humans? Substantial public and professional concerns have developed recently in the eastern United States regarding this question. On the one hand, the prospect of humans managing a native species in national parks seems to belie the very purposes for which the NPS was established. On the other hand, many wildlife biologists contend that ecological diversity on NPS areas might better be maintained by controlling deer. This question has become a high priority for the NPS. In 1989, the NPS held a workshop on deer ecology and management (Soukup et al. 1990). In 1990, a NPS symposium on management of deer and large mammals was held at the 55th North American Wildlife and Natural Resources Conference to focus on the biological, ecological and political ramifications of this question.

In this paper, I will argue that a policy designed to manage and control deer in many parks is justified ecologically. My argument will be based on a review of relevant literature. If left uncontrolled, these deer herds can become so numerous that they may adversely affect associated plant and animal communities, and, hence, alter ecological diversity and succession.

Historical Perspective

The history of deer populations in North American provides an important basis upon which an overpopulation of deer can be defined. Herein, I define an "overpopulation" of deer as that level of deer density at which alterations in the native plant and animal communities are evident, when compared to those communities that would typify the climax stage of ecological succession.

Densities of North American deer herds in precolonial times have been estimated at 8–11/mi^2 (McCabe and McCabe 1984). These pristine herds probably were controlled by Native Americans, deer predators and other ecological forces (McCabe and McCabe 1984). In the 19th Century, a burgeoning human population of European settlers instituted widespread predator eradication, extensive habitat alterations, and excessive hunting pressure, all of which extirpated white-tailed deer from many areas in the eastern United States (McCabe and McCabe 1984). By the mid-20th Century, natural resource conservation efforts had led to widespread establishment of national forests, national parks, wildlife refuges, etc., as well as widespread transplantation programs to restore deer herds. Similar efforts to restore native predators were not instituted; deer were being restored primarily as a game species. As habitat quality was restored and deer were protected from overexploitation, deer populations rebounded within a matter of a few decades and represented a premier example of successful wildlife conservation (McCabe and McCabe 1984).

Overpopulation of the restored deer herds generally is not a problem in most areas, because public hunting programs can control deer herds (Behrend et al. 1970). However, the wildife profession was slow to learn the importance of controlling deer herds. After having grown out of an era of protecting deer and "bucks-only" hunting, the profession was reluctant to accept the notion that deer herds could become overpopulated, even when this notion was advocated by the "father of game management" (Leopold et al. 1947). Given that this was the case on areas where deer hunting was allowed, it should be obvious that on many eastern national parks, where neither natural deer predators nor hunting occur, an overpopulated deer herd can be predicted.

Deer Population Control, Ecological Disturbance and NPS Areas

White-tailed deer possess a substantial variety of antipredator adaptations (Mech 1984), which obviously indicates that they evolved as a prey species. Thus, acute mortality (e.g., predation) probably always has been a major component in the complex of factors that control deer populations. Behavioral interactions and social pressure among conspecifics, which control some animal populations (Wynne-Edwards 1964), do not seem to be operative in deer. For example, supplementing feed can overcome the limits of an area's natural food supplies, and will allow a deer herd to increase more than five fold (Ozoga and Verme 1982). Therefore, behavioral or social controls of deer density probably are inadequate to prevent adverse ecological effects.

Some might argue that starvation and poor reproduction demonstrated by deer in overpopulated herds is evidence that the herd is regulating itself. However, natural regulation of most large ungulates should include predator-ungulate interactions as well as ungulate-habitat interactions (Peek 1980). Starvation and disease are not acute mortality factors, but rather provide only chronic control over a population (Eve 1981). Under these conditions, deer herds can remain at high levels for many years until starvation, disease or severe winter weather reduce the herd. By this time, adverse ecological effects can already have occurred. Short-term reductions (2–5 years) in the deer herd as a result of these natural die-offs probably will not allow recovery of the natural communities in the area. Plant and animal community recovery may require several decades to occur, especially in areas where seed banks may have been depleted because of chronic overbrowsing by deer. Thus, allowing a deer herd on an NPS area to regulate itself through chronic mortality factors is unacceptable ecologically because of the adverse effects on plant and animal communities that can result from chronic overbrowsing (to be detailed in the next two sections).

Today, many eastern NPS areas (e.g., parks, historic sites, monuments) are surrounded by intensive residential, agricultural and commercial developments. Therefore, they actually represent natural "islands" or forest fragments in an otherwise contiguous expanse of urban and suburban environments. The variety of secondary successional habitats that surround these areas creates an edge effect that can produce very large deer populations, even within natural reserves of considerable size (Alverson et al. 1988). Unless an adequate level of acute mortality factors are present to control these deer herds, they likely can become chronically overpopulated.

Deer overpopulation can be defined simply as too many deer in a particular area. Yet the concept of "too many" can include a variety of social, biological or ecological definitions. There can be too many deer in an area from the standpoint of public safety (e.g., excessive deer/vehicle collisions), agricultural damage and damage to landscape plantings (social). There can be too many deer in an area from the standpoint of maximizing the health and productivity of deer herds, such as in game management programs (biological). There also can be too many deer in an area from the standpoint of adverse effects to the associated plant and animal communities (ecological). The last definition of deer overpopulation provides the ecological justification for controlling deer on eastern national parks.

Too many herbivores in a particular area can alter plant communities and set back ecological succession. This process has been termed "retrogression" or reverse succession (Stoddard et al. 1975:163). If the effect of too may herbivores occurs for a sufficient amount of time, then a disturbance climax of "disclimax" (Odum 1971:267) community will develop instead of the natural climax community normally characteristic of an area's ecological conditions.

Natural disturbances that significantly alter plant communities and set back ecological succession certainly were an integral part of North American ecosystems during precolonial times. Temperate deciduous forests are typified by small-scale, frequent disturbances, such as the death of individual large trees. Shade-tolerant saplings in the understory are suppressed until these disturbances create a vacant spot (Hunter 1990). Indeed, contemporary ecological thought considers the periodic occurrence of disturbance as desirable in natural ecosystems because of its importance in maintaining diverse gene pools and ecosystem resiliency (Walker 1981). However, considering that many NPS areas today are essentially isolated "islands" surrounded by man-made environments, there may be few sources of native plant and animal species for recolonization of these areas following disturbance. To quote Noy-Meir (1981:243): "In coevolved systems plants would have been selected for resilience (ability to recover after overgrazing). In all probability plant resilience and herbivore dispersal have prevented extinctions of plant and animal species (except in rare events) in 'natural' systems in the past, even when large fluctuations occurred. But it cannot be taken for granted that these mechanisms are equally effective in the wildlife and nature reserves of today, with confinement and other man-made changes."

The term "carrying capacity" often has been used to characterize a point beyond which overpopulation can result. Yet, the concept of carrying capacity sometimes includes animal health, productivity and sustainable harvest. Such an application introduces a value judgment "as to what is best for the population" (Caughley 1981:9). The more ecologically correct concept of carrying capacity is the point at which an animal population is at equilibrium with its environment (Caughley 1981), assuming all of the natural controlling mechanisms are present. This is the critical point in regard to deer herds on some NPS areas. All of the natural, ecological mechanisms that controlled deer herds historically are not present in many NPS areas today. These "incomplete," isolated natural preserves have been set aside and are expected to function as self-regulating ecological systems in which little if any management by humans will be required. Yet, these areas lack many of the important acute mortality factors (i.e., hunting by Native Americans and deer predators) that were so important in controlling deer herds historically. Herein lies the dilemma. In the absence of a complete ecosystem, can these preserves be self-regulating as they were before the intervention of the European colonist? Without adequate levels of acute mortality (i.e., control), deer herds on these areas can occur at unnaturally high levels, and can adversely affect the associated plant and animal communities within these preserves (i.e., a "displaced equilibrium" will occur [Caughley 1981:10]). The following two sections provide detailed examples of these adverse ecological effects.

Deer Overpopulations and Plant Community Effects

Deer browsing in eastern deciduous forests is a significant problem to foresters attempting to regenerate stands after harvest (Marquis 1981). In these instances, the effects of deer browsing on plant communities are very obvious. However, the effects of deer overbrowsing in a mature forest are less dramatic and require decades to document. Botanists noted as early as the 1930s that excessive browsing by an overpopulated deer herd could lead to a significant decline in understory vegetation and tree reproduction in virgin northern forests (Hosley and Ziebarth 1935, Hough 1965). Hough (1965) conducted a 20-year photographic study of a 4,080-acre virgin hemlock (*Tsuga canadensis*)/hardwood forest in northwestern Pennsylvania. He concluded that heavy browsing pressure by deer weakened and killed smaller stems, and thereby significantly reduced understory vegetation and the advance-growth reproduction of hemlocks and hardwoods. He noted that 50–100 years were required to develop advance-growth reproduction in the understory of these climax forests, and that chronic overbrowsing by deer could prevent reproduction of the climax tree species. He warned that unless deer were kept "in balance in this particular forest stand" (Hough 1965:373), then this virgin, climax forest could be changed into a secondary successional stage as the older trees in the overstory dropped out with age, and comparable species in the smaller-size classes were not present in the understory to replace them. He further pointed out that "such a change would take place very slowly; and many people might deny that the white-tailed deer had any part in the process" (Hough 1965:373). In a similar study on another virgin forest in Pennsylvania, Whitney (1984:404) concluded that very high deer population levels were "one of the more important determinants of forest structure in the Allegheny Plateau area of northern Pennsylvania over the last 50 years."

Some botanists have used exclosures to document the specific effects of deer browsing on forests. Anderson and Loucks (1979) determined that deer adversely affected the ability of hemlock to replace itself as the dominant tree species in mature Wisconsin hemlock forests. In their study, sugar maple (*Acer saccharum*) replaced hemlock when both were browsed heavily. Ross et al. (1970) observed similar effects on tree reproduction in red pine (*Pinus resinosa*) forests of north-central Minnesota from excessive deer browsing.

The best evidence of the adverse effects of an overpopulation of deer on plant communities and ecological succession was provided in a recent study in a 60 to 70-year-old Allegheny hardwood forest in Pennsylvania where deer densities were controlled experimentally in 160-acre enclosures that had been clearcut, thinned or uncut. Tilghman (1989) demonstrated significant reductions in tree seedling height, density, and diversity in all enclosures where deer densities reached 40–80/mi^2. At these higher deer densities, she documented a shift in forest succession to a near-monoculture of black cherry (*Prunus serotina*), and profound changes in the composition of herbaceous ground cover, all of which were the direct result of overbrowsing by deer.

Perhaps one of the most significant plant indicators of an overpopulation of deer in an area is the occurrence of "bark stripping" on trees. During winter in Catoctin Mountain Park, Maryland, deer strip significant amounts of bark from elms (*Ulmus* spp.) (Warren and Ford 1990). Bark stripping has been proposed as an indicator of low forage availability for ungulates (Miquelle and Van Ballenberghe 1989). Bark stripping by deer represents an exacerbation of the overbrowsing problem in forests. The adverse effects of overbrowsing on understory vegetation and seedlings are further compounded by the effect of bark stripping on midstory and overstory trees via increased susceptibility of trees to disease and mortality (Miquelle and Van Ballenberghe 1989).

Several studies have been conducted on the effects of too many deer on vegetation in NPS areas. In a study of plant communities in the Great Smoky Mountains National Park in Tennessee, Bratton (1979) documented a reduction in the number of plant species, a loss of hardwood species and a predominance of conifer species in an area of the park heavily populated by deer compared to an ecologically similar control area with fewer deer. On Gettysburg National Military Park, Pennsylvania, Storm et al. (1989) reported that excessive browsing by deer reduced the number and vigor of tree seedings. They warned that regeneration of overstory trees, and hence maintenance of historic battlefield woodlots, would likely be jeopardized in the future. On Saratoga National Historical Park, New York, deer browsing prevented recruitment of tree seedlings to saplings; these adverse effects on vegetation were most pronounced toward the center of the park (Soukup et al. 1990). Bratton and Kramer (1990) determined that overbrowsing by deer on Cumberland Island National Seashore, Georgia, was helping suppress live oak (*Quercus virginiana*) seedlings, sprouts and saplings in the forest that dominates the island.

Interestingly, in some of the smaller eastern NPS areas, deer mortality from deer-vehicle collisions is sufficiently high so as to control the deer herd to the point that adverse effects to the vegetation have not been observed (Valley Forge National Historical Park, Pennsylvania [Cypher et al. 1985]; Chickamauga National Battlefield Park, Georgia [Project Statement No. CHCH–N–008; Chickamauga-Chattanooga National Military Park Resource Management Plan]). Evidently, deer-vehicle collisions in these NPS areas are helping to control the deer herd, and thus prevent adverse effects on the vegetation.

One significant source of concern for the NPS is the effect of deer on rare and endangered plants. In the Great Smoky Mountains National Park, Bratton (1979) noted that overbrowsing by deer reduced plant diversity, and potentially threatened the less abundant plant species. Numerous plant species on Catoctin Mountain Park, some of which are considered very rare by the Maryland Department of Natural Resources' Natural Heritage Program, have been threatened by deer overbrowsing (Warren and Ford 1990).

In summary, numerous studies have documented that overbrowsing by deer can decrease tree reproduction, understory vegetation cover, plant density and plant diversity. Dramatic and unnatural alterations in succession of the plant community have been shown and can be predicted under conditions of continuous overbrowsing by deer for long periods of time.

Deer Overpopulations and Animal Community Effects

The previous section provided evidence of the significant and adverse effects of deer overbrowsing on plant communities. If deer can alter natural plant communities and successional patterns, then they very likely can affect the associated animal communities that depend on this vegetation.

Since 1983, a research team working in a northern hardwood forest in Massachusetts has been conducting a comprehensive study of the interactions among deer densities, plant community characteristics and small mammal community characteristics (Healy et al. 1987, Brooks and Healy 1988). They documented that chronically high deer population levels can alter the structure and composition of habitat to the detriment of some small mammal species (Brooks and Healy 1988). Their high deer-density areas contained lower tree densities, fewer forb species and more graminoid species than their low deer-density areas (Brooks and Healy 1988). Because of these habitat changes, they noted lower abundances of southern red-backed voles (*Clethrionomys gapperi*) and short-tailed shrews (*Blarina brevicauda*), but higher abundances of white-footed mice (*Peromyscus leucopus*) in the high versus low deer-density areas (Brooks and Healy 1988). Indeed, the effects they noted on the small mammal community from deer overbrowsing were greater than they observed as a result of silvicultural treatments (thinnings).

Overbrowsing by deer in harvested northern hardwood forests also can affect the animal communities in these intensively managed forests. Scott and Yahner (1989) found greater use by snowshoe hares (*Lepus americanus*) and Dessecker and Yahner (1987) found greater breeding-bird community species richness and diversity on recent (≤ 6 years old) clearcut stands in north-central Pennsylvania that had been successfully regenerated (≥70 percent of plots stocked with desirable tree species ≤ 5 feet tall) as compared to those not successfully regenerated (≤ 50 percent stocking level). Overbrowsing by deer was the major cause of unsuccessful regeneration.

Casey and Hein (1983) conducted a study of breeding-bird communities on a 5,200-acre mature northern forest in southwestern Pennsylvania that had been managed as a wildlife research reserve for 27 years, during which very dense populations of deer, elk (*Cervus elaphus*) and Mouflon sheep (*Ovis musimon*) were maintained by supplemental feeding. In comparisons to surrounding areas that had been subjected to much less browsing pressure, they observed significantly less understory vegetation density inside the wildlife reserve, which they attributed to overbrowsing by the ungulates. In their comparisons of the bird community inside versus outside the wildlife reserve, they found no differences in overall abundance of birds or species richness; however, there was a significant shift in the bird species composition inside versus outside the reserve. Some bird species commonly associated with forest undergrowth (e.g., wild turkey [*Meleagris gallopavo*], black-and-white warbler [*Mniotilta varia*] and black-throated warbler [*Dendroica virens*]) were completely absent inside the reserve.

Thus, an overpopulation of deer also can alter the associated mammal and bird communities in a deciduous forest ecosystem. These adverse effects may not be manifested by changes in overall abundances or diversity indices. Rather, as was noted above, these alterations may take the form of changes in the species composition within these animal communities. I was unable to locate any references on the effects of overbrowsing by deer on associated amphibian, reptilian or invertebrate communities, but these also may be altered, considering the importance of microclimate features to these animals.

Identifying Overpopulations of Deer on NPS Areas

Absolute deer densities are not required to diagnose an overpopulation in NPS areas. Indeed, methods for estimating absolute densities of deer in an area are generally variable, time consuming and costly (Hayne 1984). Even if absolute deer densities could be obtained readily, an important question would still remain: "How many deer should there be in the area?" The answer to this question varies seasonally and among years, and depends on one's objectives. Thus, it is very difficult to give an exact, correct answer.

The data needed to diagnose an overpopulation of deer and recommend a program of control can be obtained from the deer population itself, as well as from long-term ecological monitoring programs designed to characterize changes in the plant and animal communities in a particular park. The NPS has recently developed detailed guidelines for long-term vegetation monitoring (Soukup et al. 1990, S.D. Bratton personal communication: 1990).

The major justification for any plant community monitoring program designed to evaluate the status of deer populations must be to characterize the complete natural diversity of vegetation in the area. Without complete and detailed knowledge of all vegetation in an area, natural resource managers cannot adequately characterize the effects of overbrowsing on plant communities. Plant ecologists have documented the composition of several virgin, climax North American forests (e.g., Hough 1965) that might be used as a standard against which the current seral stage of a particular forest could be judged. In particular, rare and endangered plants that may not play an obviously important role in the historic or natural scene of an NPS area to the casual observer, add significantly to the biological diversity of the area. It is these species that can be affected most seriously by deer. Therefore, rare and endangered plants should be monitored very closely.

NPS Policy on Controlling Native Species

Congress requires the NPS to manage parks to maintain the abundance, diversity and ecological integrity of native plants and animals in natural portions of parks (16 USC 1, 2–4). In addressing its Congressional mandate, the NPS has specific management policies that protect native animal populations from harvest, removal, destruction or harm through human action.

NPS policy permits the control of native species under two specific circumstances. First, "unnatural concentrations of native species" can be controlled, providing the control program is "based on scientifically valid resource information" and after "provisions for public review and comment" (National Park Service 1988—Chapter 4:6). Second, any native populations that are pests can be controlled under six specific criteria: (1) to prevent the loss of the host or host-dependent species; (2) to prevent outbreaks of the pest; (3) to conserve threatened or endangered plant communities;

(4) to preserve the historical integrity of cultural resources; (5) to protect plants and animals in developed zones; and (6) to manage a human health hazard or protect public safety (National Park Service 1988—Chapter 4:13).

Therefore, NPS policy would permit the control of deer. The agency's management policies also specifically state that "Ecological processes altered in the past by human activities may need to be abetted to maintain the closest approximation of the natural ecosystem where a truly natural system is no longer attainable" (National Park Service 1988—Chapter 4:2). I contend that the high deer population levels in many eastern NPS areas are the result of past human activities (e.g., historic alterations of natural habitats, isolation of NPS areas and the unsuitable habitats that currently surround many of these areas, extermination of natural predators, lack of humans as predators, and restoration of deer herds without complete ecological controls). Furthermore, it is unlikely that a "truly natural system" will ever be attainable in most eastern NPS areas, given their relatively small size and the demands humans have placed on adjacent lands. Therefore, it is incumbent upon us to help maintain the natural equilibrium in these preserves. Conservation authorities in South Africa, where national parks also have been set aside to maintain the diversity of life forms in a naturally interacting and functioning ecosystem, have used culling (shooting) in their efforts to maintain a natural equilibrium in their national parks (Hanks et al. 1981).

One well-known natural preserve decided decades ago to control deer to prevent vegetation damage. The 1,146-acre George Reserve in Michigan was established so the area could "follow its natural course without interference by man" (McCullough 1979:3). In the mid-1930s, after deer had been reintroduced to the area for less than 10 years, "it was imperative that the deer population be artificially controlled by man, even though such action ran counter to the basic philosophy of noninterference in the natural processes of the area. It was recognized that part of the problem was the lack of large predators in the area, and the role of the predator had to be played by man" (McCullough 1979:8). Interestingly, "deer are the only animals (or plants) on the Reserve that are artificially controlled" (McCullough 1984:239).

Management Alternatives to Control Deer on NPS Areas

It is beyond the scope of this paper to thoroughly discuss the alternatives, and all of their ramifications, available to control deer on eastern NPS areas. My primary purpose here is to argue that deer should be controlled in many NPS areas. The specific alternatives that may be acceptable (especially publicly and politically) to accomplish this task will vary widely among individual NPS areas (Soukup et al. 1990).

Conclusion

Almost three decades ago, professional wildlife biologists first advised the NPS that control of native animal populations in some NPS areas may be required in order to maintain these natural areas as closely as possible to their natural state (Leopold et al. 1963). To maintain vegetation communities in these preserves, one must consider managing the animal populations that these communities support. If deer are left to control themselves, then unnatural alterations of associated plant and animal communities likely will occur. The goal of the NPS in this regard should not be to manage and control deer, but rather to ensure the natural functioning of both plant and animal communities to the greatest extent possible unimpeded by human actions. The extent to which a deer herd, largely because of past human actions, has adversely affected a park's natural communities and further threatens future successional changes, is sufficient justification to control deer.

The NPS must try to preserve entire ecosystems. When one component of the ecosystem (e.g., deer) jeopardizes the other native plant and animal communities in an area, then drastic and nontraditional actions are justified to ensure the natural functioning of all communities in the ecosystem. The policy of noninterventionist preservation in regard to native deer in many NPS areas must end if the complete ecological integrity and biological diversity of these areas are to be preserved for future generations.

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Values and Science: White-tailed Deer Management in Eastern National Parks

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Introduction

The process of setting natural resource management objectives imposes a set of values that define how we think a particular unit of land and its resources ought to be utilized. Resource managers (hereafter referred to as managers) use the products of science to guide the decisions that ultimately determine what must be done to achieve the desired objective.

Managers often provide rationale for action by couching their intentions in terms which seem anchored in science, but are ill-defined or are judgements of value. Resource management plans often contain language like, ''in order to maintain the herd *in balance* with carrying capacity. . .'' or ''to ensure the *health* of the ecosystem. . . .'' Shibboleths like these are rarely intentional, but are symptomatic of a larger problem: value systems and beliefs are being confused with scientific facts. More often not, this leads to hazy thinking about how nature functions.

With respect to the management of white-tailed deer (*Odocoileus virginianus*) in eastern national parks, we believe that the confusion of values with scientific facts has impaired the ability of managers to articulate realistic management objectives. Consequently, it has been difficult to effectively apply scientific information to management issues. Our intent is to review how value systems and beliefs may affect approaches to the management of deer populations in national parks. We provide an example that illustrates the problem, and propose a framework within which science and management can be integrated more effectively.

Conceptual Background

Much of the confusion of science and values arises from the concept of carrying capacity as it relates to the issue of overabundance of large herbivores. For our purpose, we will summarize the concept of carrying capacity and issue of overabundance, in turn.

Carrying Capacity

There are two working definitions of carrying capacity used in the wildlife literature (Caughley 1979). One refers to the density of animals at which a maximum sustained yield is taken—*economic carrying capacity*. The other refers to average density of an unhunted population of herbivores measured over a long period of time—*ecological carrying capacity*.

The former is usually indexed by a characteristic composition of vegetation (or alternatively, a characteristic level of animal performance) and is traceable directly to the range management ancestry of the wildlife profession. Ecological carrying capacity is defined by the interaction between plants and herbivores. It is that point where the herbivores and plants achieve an accommodation in numbers through mutual, dynamic interaction.

The confusion surrounding the concept of carrying capacity lies in the determination of which definition is the *appropriate* one. Ecological carrying capacity describes the endpoint of a process that is observed in nature when herbivore populations are left to their own accord. Economic carrying capacity, on the other hand, describes an arbitrary point along the growth trajectory that is somehow better or more appealing to managers.

For example, when a deer population grows from low density, it usurps more and more of the resources available in the environment (i.e., food, cover, etc.). Competition among deer for these finite resources intensifies as the population increases in number. Changes in plant species composition and abundance, declining deer physiological condition and age-specific survival and reproduction are common milestones observed during this process. Opinions diverge in the interpretation of these changes, however. Some managers view them as part-and-parcel of the interaction between deer and vegetation. Others view them as indicators of ecosystem degradation.

The trap is in believing that economic carrying capacity, because it produces the properties which some may find desirable, is legitimate on ecological grounds. Such logic is widespread in deer management programs which emphasize animal performance like larger antlers, heavier body mass or higher productivity. This same logic is often disguised in the currency of the plant ecologist. The use of plant diversity or biomass, community composition, and vigor to index carrying capacity imposes a preconceived notion about what the condition *should* be (e.g., deer exclosures describe a vegetation developing in the absence of browsing or grazing). The distinction between economic and ecological carrying capacity is that the latter implies nothing about a desirable condition.

Overabundance

The issue of overabundance is appropriately addressed in the same context as carrying capacity. Often, a conclusion of overabundance is the result of misidentification of economic carrying capacity for ecological carrying capacity (Caughley 1980). The intrusion of value systems and beliefs is common in discussions of overabundance. Popular examples we have encountered include: (1) deer are too numerous for their own good; and (2) deer depress the densities of favored species.

The first example is often provided as a biological justification for reducing deer populations, and is cast in terms of the health and reproductive vigor of a deer population. Below ''normal'' reproductive rates, body weights and antler beam diameters, and especially starving animals, are considered indicators of a population that is too high for its own good. Ecologically speaking, these are descriptions of various states encountered along the trajectory of a population of herbivores growing from low density to high. Whether or not such states should be allowed by management is clearly a value judgement based a perception of what is ''normal''. The second example illustrates how individual bias intrudes into the management decision-making process. Not all species are valued equally (Caughley 1985).

Policies, Goals and Objectives

The process of formulating management policy based on value judgements is not wrong, it simply must be recognized for what it is. To illustrate, the guidelines for natural resources management in the National Park System are provided in the National park Service (NPS) Management Policies (USDI 1988). These provide the goals or general targets toward which management moves. Because they are general, there exists latitude for interpretation. The interested reader can trace the evolution of this interpretation with respect to the management of wildlife populations on national parks (*see* Leopold et al. 1963, Houston 1971, 1982, Despain et al. 1986, Shepherd and Caughley 1987, Boyce 1989, NPCA 1989).

Deciding just how these goals are approached defines the management objectives. The objectives identify the actions to be taken. They are, by definition, judgements of value. Managers use science in deciding which option is technically more suitable to achieve the objective. Science also guides the manager by providing an understanding of the process of interest. Science often defines the limits of change, but only management can define the limits of *acceptable change*.

A comparison of two eastern historical parks, Saratoga National Historical Park (SNHP) and Gettysburg National Military Park (GNMP), provides an interesting example of the interaction of management and science. These parks share several commonalities. Deer populations are relatively dense (approximately 50–60 deer/km^2), and are, in general, perceived to be a management problem in both parks. The goals at SNHP and GNMP are to restore the historical landscapes to the time of battles fought in 1777 and 1862, respectively. Both studies extensively documented biotic effects of deer on park vegetation. At SNHP, a five year study concluded there were no grounds for active management of deer at the present time. At GNMP, a similar study recommended substantial reduction the deer population. Why do the recommendations for management differ?

At SNHP, park managers have yet to determine how the vegetation appeared in 1777. Without description of the desired vegetation patterns, it is not possible to determine whether deer are in conflict with park objectives. Once these descriptions are complete, specific management objectives can be formulated and criteria established to identify when deer are in conflict.

At GNMP, knowledge of the historical landscape is more complete. Agricultural crops were part of the historical landscape, and research has demonstrated that deer are precluding the growth of crops in certain areas of the park. Because the linkage between deer numbers and failure to achieve a stated objective is established, park managers are in position to propose action that can be anchored to science.

Hypotheses, Paradigms and Ideologies

The controversy surrounding management of white-tailed deer populations in eastern national parks has polarized managers, scientists and the public into two camps: those who believe deer populations should and must be manipulated, and those who believe otherwise. At first glance, the problem appears insolvable. However, a resolution is possible if both camps will agree to issues which can be argued on scientific grounds. This is not a simple task.

The institutionalization of value systems is a subtle process, evolving over long periods (i.e., careers) of time. The parsing of values and beliefs from facts is therefore difficult and evasive. We have attempted to dissect some of the more popular propositions regarding the management of white-tailed deer. We present them in full knowledge that we too are victims of our own making.

These propositions fall into three categories—hypotheses, paradigms and ideologies (Caughley 1989). An hypothesis is a tentative assumption made in order to draw out and test its logical or empirical consequences. Hypotheses are debatable, subject to scrutiny, but above all are falsifiable in the face of evidence. Our candidate proposition in its vernacular form is: *deer populations must be managed because they are incapable of managing themselves*. It is a compelling statement, but lacking in detail. Opinions about what self-management means clearly determines the validity of this proposition, and therefore renders it unfalsifiable. If we mean "self-regulation" in it technical sense, then some rigor can be injected and an hypothesis stated. The point is, our terminology must be precise in definition.

A paradigm is an outstanding example of an "inherited" ideal or mode of thought that is not amendable to decisive testing. It must be evaluated on the merits of circumstantial evidence. Our candidate proposition is: *the number of white-tailed deer throughout its historical range is now greater than during pre-Columbian North America*. In a seminal volume on deer ecology and management, McCabe and McCabe (1984) go to great lengths describing and analyzing the available information on this subject. However, it is unlikely that we will ever have sufficient data on historical deer population abundance to formulate a solid test.

An ideology is a systematic body of concepts characteristic of an individual, group, or culture. Ideologies can be supported or criticized, but cannot be invalidated. Ideologies are replete with value judgements and beliefs, neither of which can be argued on technical merit. Our candidate proposition for inclusion into this category is: *white-tailed deer damage vegetation*. The operative word is, of course, "damage." A quick check of the reader's personal biases with respect to this statement can be made by asking in *what sense* do deer damage vegetation?

In short, the difficulty in resolving issues of deer and vegetation management is our failure to recognize these propositions as paradigms and ideologies, and to structure key elements of the debate in a manner that can be treated by science. Hypotheses can be falsified, and Caughley (1989) suggests that it is precisely to avoid that prospect that ideologies are often stated in abstract and ambiguous terminology.

Recommendations

The variety of opinions expressed about why white-tailed deer populations should be manipulated reflects the narrow context within which this species has been traditionally managed. High deer populations are viewed as ecological aberrations rather than the products of complex interaction between an herbivore and vegetation. For temperate grazing systems, we know very little about this interaction (Putman 1986), especially in human dominated landscapes.

Our concern is not so much the decision to, or not to manipulate deer populations. Rather, it is how (i.e., logic) and why (i.e., philosophy) the manager arrived at that decision. Lack of attention paid to these two fundamental thought processes leads to goals or objectives which, in a management context, may be ecologically unattainable and politically unsustainable.

The Yellowstone fires of 1988 provide an example of how NPS fire management policy was sustained despite significant political backlash. The goal of management is to minimize interference by humans in natural processes of the Yellowstone ecosystem (Houston 1971). One management objective associated with this goal is to let fires burn when they meet specific criteria. During summer and fall of 1988, the goal was almost universally accepted. The management objective was not.

The NPS sustained much of its management policy in Yellowstone, in part because it was securely anchored politically, and in part because it was able to muster scientific evidence in support of its position. Politically, the management goals and objectives had been carefully communicated and reviewed within all levels of the bureaucracy. There was broad understanding and "ownership" of the policy. Scientifically, the NPS was able to provide data and experts to support the hypothesis that fires burning large portions of this ecosystem were part of, and essential to, the ecology of the region.

Setting Reasonable Objectives

Setting objectives for the management of deer in eastern national parks requires the same attention to the political and scientific anchor points. For example, a manager beset with complaints about the high accident rate caused by "park deer" must do something or, at least, consciously decide to do nothing. A goal is formulated: minimize deer/vehicle collisions in and on the periphery of the park. After examining the situation, the manager decides that the most reasonable objective is to reduce the deer population. While the goal is unlikely to be challenged, the objective is, and the direction of the challenge will depend on the technique used for achieving the objective.

At this point, the manager must initiate two parallel activities. One initiative is to involve the internal bureaucratic hierarchy and the external public interest groups in the decision-making process. Most agencies require various levels of compliance toward that end. The other initiative is to request that scientists establish a quantitative baseline of the problem at hand, provide an analysis of all reasonable alternatives for addressing the objective and assess the techniques to be employed in each alternative.

Sustaining Management Policy

Once the management action has been selected, there is strong political and scientific merit in casting the implementation as an experiment. Sustaining the management action will require continued attention to defining issues precisely and bringing scientific data to bear. Assessment and justification of the technique selected is likely to be ongoing, and in the long-term, reasoned decisions will likely depend on quantification of costs and benefits.

Accomplishing these tasks will not occur quickly. In laying political foundations, managers should anticipate long learning curves. The various interests involved will have to become accustomed to listening to other values before they can provide meaningful input.

Summary

We have asserted that natural resource management objectives are inherently value driven. They reflect society's interests and aspirations for a unit of land, as translated by the political process. Reasonable goals seem easy to articulate. Most people will come to quick agreement that preserving historical scenes or ecological processes are appropriate goals. The difficulty arises in translating these goals into objectives. In casting objectives, we add definition to the goals. While goals are perceived as shades of grey, objectives tend to be viewed in high contrast.

Values and science are inextricably linked in the management of all natural resources. Values ultimately determine the target. Science guides and supports management in resolving issue and achieving the target. However, we must be cautious that we integrate science into the value system, and not integrate the value system into science.

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Elk, White-tailed Ptarmigan and Willow Relationships: A Management Dilemma in Rocky Mountain National Park

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Introduction

Conflicting demands of wildlife management in national parks are not recent in origin and many conflicts date to park establishment (Wright et al. 1932, Leopold et al. 1963). Policies that direct wildlife management in national parks originated with the first survey of faunal relations in the national parks by George M. Wright, Joseph S. Dixon and Ben H. Thompson (1932). Their recommendations were reiterated in the "Leopold Report" in 1963 by the Advisory Board on Wildlife Management, comprised of A. Starker Leopold, Stanley A. Cain, Clarence M. Cottam, Ira N. Gabrielson and Thomas L. Kimball.

The most recent Management Policies (Natl. Park Serv. 1988) generally support the earlier philosophy. The National Park Service will perpetuate the native animal life and the natural ecosystems of parks. Management policies will minimize human impacts on natural population dynamics. Animal populations may be controlled if required for park ecosystem maintenance. Any decision to initiate a control program will be based on scientifically valid resource information obtained through research.

Manipulative or destructive research activities are not generally permitted within parks, although exceptions may be granted. Research activities that might disturb visitors or require waiver of a regulation may be allowed only pursuant to the terms and conditions of an appropriate permit. The definition of what is disturbing or detracting from park values is left to individual superintendents who are responsible for issuing the permits.

Elk and White-tailed Ptarmigan

Both Rocky Mountain elk (*Cervus elaphus nelsoni*) and southern white-tailed ptarmigan (*Lagopus leucurus altipetens*) are native to Rocky Mountain National Park. However, elk in the vicinity of Estes Park and the area that became Rocky Mountain National Park (1915) were close to extirpation by 1880 because of market hunting and competition with domestic livestock on winter range. In 1913 and 1914, 49 elk were transplanted from Yellowstone National Park. The herd increased rapidly at about 16 percent per year until 1944 when population management was initiated (Packard 1947, Stevens 1980a). Elk were first reported to winter in the alpine in 1933 during the initial increase in population numbers (Ratcliff 1941). Population control, primarily by shooting with some trapping and transplanting in the later years, was conducted from 1943 to 1968, primarily on low elevation ranges (Stevens 1980a).

Although precise population data are unavailable, the elk population associated with Rocky Mountain National Park has increased about 67 percent since population reduction programs were halted (Stevens 1980a, Bear et al. 1989). Since that time the only population control has been public hunting outside park boundaries. Crude estimates indicate an increase from about 1,000 elk in 1968 to more than 2,500 in 1982 (Bear et al. 1989) and at least 3,000 in 1990. Elk observed wintering in the alpine have increased from 29 in 1933 to over 300 in 1976 (Stevens 1980b). Recent observations indicate that numbers may have stabilized at somewhat less than 300.

Elk winter use of the primary white-tailed ptarmigan study area, Trail Ridge, also increased proportionally. The highest count was 182 in 1976. Bear (1989) estimated the population in 1982 at about 175. Since then the wintering population has been about 100. In addition to the wintering population, many elk that winter on the east slope also cross alpine areas, especially Trail Ridge, in both spring and fall migrations and may spend considerable time enroute. Elk use willow (*Salix* spp.)-dominated communities extensively at all elevations in Rocky Mountain National park and often forage on willow (Harrington 1978, Hobbs et al. 1981).

Historic data on abundance and distribution of white-tailed ptarmigan in Rocky Mountain National Park are not available. However, observation records of ptarmigan in the files of the National Park Service (Estes Park) date to 1934. Most of these records were from along major trails and Trail Ridge Road and indicate ptarmigan were widespread within alpine habitats. Intensive studies of white-tailed ptarmigan in Rocky Mountain National Park began in 1966 (Braun 1969) and have continued through 1990 (Giesen 1977, Braun and Giesen unpublished data). The data indicated the ptarmigan population was high from 1966 through 1969 (Braun and Rogers 1971). The population then decreased until the mid-1970s, increased again in the late 1970s, and then declined below previous low densities in the early to mid-1980s.

White-tailed ptarmigan in Rocky Mountain National Park forage almost exclusively upon willow buds and twig tips during winter and early spring (May and Braun 1972). Presence and abundance of willow markedly affects ptarmigan distribution and abundance during late fall, winter, (Braun and Schmidt 1971, Braun et al. 1976), and early spring (Braun 1969, Schmidt 1988) in Rocky Mountain National Park and elsewhere in Colorado.

If white-tailed ptarmigan along Trail Ridge Road are cyclic at 7–10-year intervals, the data indicate the population was lower than anticipated in the 1980s. Observations of elk, and effects of their browsing of willows in late fall, winter and early spring in ptarmigan-use areas, suggested cause and effect. Thus, hypotheses were formulated, experiments were designed, and approval from the National Park Service for manipulative experiments was sought to test several hypotheses on elk/willow/ptarmigan relationships. This paper presents the available data on elk population levels, ptarmigan distribution and numbers, and willow characteristics along Trail Ridge Road in Rocky Mountain National Park and identifies dilemmas associated with managing "natural ecosystems."

Study Area

Rocky Mountain National Park in Larimer, Grand and Boulder counties, Colorado, encompasses areas from sagebrush-pine (*Artemisia-Pinus*) to alpine habitats at elevations ranging from 2,285 to over 4,345 m. The study area was principally above treeline along Trail Ridge Road at elevations of 3,400–3,720 m (Figure 1). Two study units, Tombstone Ridge-Sundance Basin and Gore Turnout-Medicine Bow Curve, were selected for intensive measurement of ptarmigan breeding densities, habitat use, ungulate pellet frequencies, and plant characteristics. These areas totaled about 5 km^2.

Topography of the area was irregular, varying from sharp peaks and ridges to gently rolling expanses. Aspects varied with site, and slope ranged from 5 to 80 percent. Granite was the major rock type, although tertiary material from a volcano

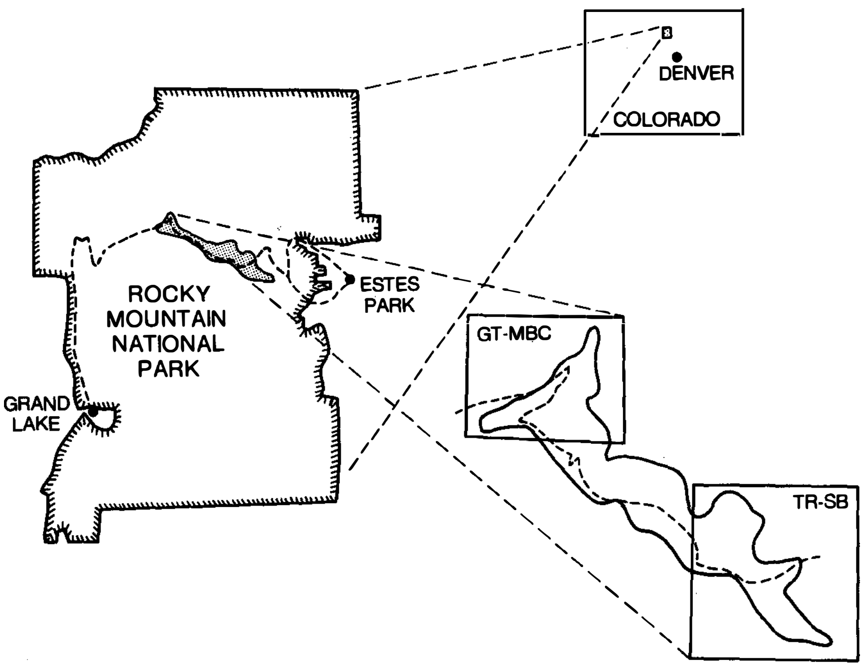

Figure 1. Alpine study sites along Trail Ridge Road in Rocky Mountain National Park, Colorado. (TR–SB = Tombstone Ridge-Sundance Basin, GT-MBC = Gore Turnout-Medicine Bow Curive).

near Mt. Richthofen blanketed much of the western portion of the study area (Quam 1938). Major plant communities included cushion plant stand, *Dryas* stand, *Kobresia* meadow, hairgrass (*Deschampsia*) meadow, Parry's clover (*Trifolium parryi*) meadow, *Geum-Carex* meadow, sedge-grass wet meadow, and *Salix-Carex* krummholz (Marr 1961, Willard 1960, 1963).

The climate of the area was typically continental, with frequent extremes in wind velocity and temperature. Prevailing winds were westerly, with occasional upslope easterly winds in April and May resulting in heavy, wet snowfalls. Maximum wind speeds occurred from November through April. Precipitation from late September until June was usually in the form of snow and sleet. Frequent short but intensive snowstorms occurred throughout spring, with moisture turning to rain in June. However, snow was recorded every month (Marr 1961, Marr et al. 1968).

Methods

Helicopter surveys were conducted in January-February in most years to identify trends in elk distribution and abundance along established flight lines. Transects were not surveyed annually in the alpine, primarily due to adverse weather conditions. The technique was effective in identifying elk distribution, but gave only crude estimates of population change. During 1979–82, a mark and reobservation study was conducted in cooperation with the Colorado Division of Wildlife (Bear et al. 1989). Elk food habits were estimated by examining elk feeding sites immediately after occupation by feeding animals. Instances of use of each plant species were recorded with one "bite" considered as one instance of use following Knowlton (1960).

Breeding densities of white-tailed ptarmigan were assessed through intensive searches on foot using binoculars to locate birds and by listening for responses to play back of tape-recorded male "challenge" calls (Braun et al. 1973). In most years, > 95 percent of the breeding birds were individually marked. Locations of pairs and unpaired males were plotted on U.S. Geological Survey topographic maps (scale 1:24000) to estimate breeding density each year.

In 1971, three 30–m vegetation transects were established in willow-dominated sites in the alpine along Trail Ridge Road and four 30–m transects were established in willow-dominated sites in the subalpine krummholz community at and just below treeline. Representative transect locations were selected using aerial photographs. Plant measurements on these seven transects followed Daubenmire (1959) and 21 20 by 50–cm plots were distributed along each transect. Occurrence and estimated percent canopy cover were recorded for each plant species in plots, and line intercept (Canfield 1941) of all shrubs was measured. In addition, one 1 by 1–m agronomy cage was staked near each transect on the Trail Ridge study area to visually demonstrate changes in plant height and cover. These seven transects, established to measure long term changes in plant cover and frequency, were measured in 1971, 1979, 1984 and 1989.

In 1989, eight (two each at Tombstone Ridge, Sundance Basin, Gore Turnout and Medicine Bow Curve) permanent 100 by 50-m plots were established to monitor ungulate pellet frequencies and willow characteristics in alpine/krummholz communities. The criterium used for plot selection was presence of site-representative willow krummholz communities. Plot boundaries were marked with metal rebar stakes. Sixty 1-m^2 sample plots were chosen randomly within each 100 by 50-m plot for measuring willow characteristics and frequencies of ungulate fecal pellets. Centers of each sample plot were marked with metal rebar stakes. Measurements obtained included counts (presence/absence) of all herbivore fecal material, and willow characteristics (height, patch perimeter, percent dead, live terminal leaders with terminal bud, browsed or dead terminal leaders, buds/live terminal leader, buds/browsed or dead terminal leaders, length of live terminal leaders, length of browsed or dead terminal leaders, and total buds). Measurements were taken in 1989 and 1990. All fecal pellets were removed from sample plots each year. Where applicable, data were analyzed with FREQ (chi-square) and GLM (ANOVA) procedures (SAS Inst. 1988).

Results

Elk

Elk use of the alpine was ascertained from 19 helicopter flights during which 1,291 elk were observed, and from ground surveys during which 2,391 elk were counted; 38 percent of the observations were along Trail Ridge. Elk distribution on the alpine in winter was affected by snow cover and amount of forage blown free of snow. The greatest occurrence of elk was on windblown areas dominated by *Kobresia* turf (65 percent of all observations) and *Geum-Carex* fellfields (32 percent). Willow types were used primarily during low snow periods or at times when wind had not blown these areas snow free and taller willows were available above the snow. Elk used alpine areas primarily for feeding but also bedded in the open on calm, sunny days. During inclement weather they generally moved into the krummholz for protection.

The largest concentrations of elk on Trail Ridge were noted during spring and fall migration periods. In late May, as melting snow opened corridors along ridge tops, elk migrated west from Estes Valley over the Continental Divide to meadows along the Colorado River Valley for calving. These elk eventually summered in areas along the Continental Divide. Elk using low elevation winter range left in mid- to late June and moved to alpine summering areas at the heads of Forest Canyon, Cache la Poudre River and Fall River. A large portion of both groups of migrating elk traversed Trail Ridge. Return to low elevation winter ranges occurred generally about mid-October with heavy use of Trail Ridge when good weather conditions prevailed into fall.

Grasses and sedges comprised the major portion (83 percent) of the diet of elk at 11 alpine feeding sites on Trail Ridge (Table 1). Forbs, represented by cushion plants, alpine sandwort (*Arenaria obtusiloba*) and clover (*Trifolium spp.*), comprised 14 percent of the diet, while willow was only 3 percent of the winter diet.

White-tailed Ptarmigan

Ptarmigan densities differed between sites ($P < 0.001$) and averaged 63 percent larger at Gore Turnout-Medicine Bow Curve than at Tombstone Ridge-Sundance Basin since 1966 (Figure 2). There was a high correlation ($r = 0.51$, $P = 0.009$) in breeding densities between the two areas suggesting that similar factors were responsible for annual changes in breeding densities. However, annual variation in breeding densities tended to be higher at Gore Turnout-Medicine Bow Curve than

Table 1. Food habits of elk in alpine and krummholz habitats on Trail Ridge, Rocky Mountain National Park.

Category/species[a]	Winter
Browse	
Salix spp.	3/18[b]
Forbs	
Arenaria obtusiloba	3/36
Anemone narcissiflora	—
Artemisia spp.	tr/9
Caltha leptosepala	—
Polygonum spp.	—
Trifolium spp.	6/18
Other forbs	5/82
Totals	14/82
Grasses/Sedges	
Carex rupestris	29/54
Carex spp.	12/71
Kobresia myosuroides	19/36
Poa spp.	16/64
Other grasses	7/14
Totals	83/100

[a]Only taxa amounting to at least 2 percent are listed.
[b]Percentage/frequency of sites.

at Tombstone Ridge-Sundance Basin, although differences were not significant ($P = 0.16$). The data indicate ptarmigan numbers fluctuated on a 7–10-year interval from 1966 through 1981 and then decreased until 1988–89. Assuming a 7–10-year population cycle, this decrease was longer than expected from 1978 through at least 1989.

Vegetation

Cover and frequency (subalpine only) of willow (*S. brachycarpa, S. planifolia*) decreased from 1971 through 1989 (tables 2 and 3). In the alpine, *S. planifolia* declined from 25 percent cover in 1971 to 17 percent in 1989. This species declined from 37 to 23 percent cover in subalpine sites from 1971 to 1989. Cover of *S. brachycarpa* declined markedly in subalpine sites (20 to 4 percent) but less so in alpine sites (24 to 19 percent) from 1971 to 1989. Cover of other species and bare ground on the alpine sites was relatively stable during this period. However, in the krummholz sites, bare ground increased while *Vaccinium* decreased and grasses (*Deschampsia caespitosa, Calamagrostis canadensis*) increased.

Analysis of data from 100 by 50 m plots revealed that ungulate pellets were more frequent ($P < 0.0001$) at Tombstone Ridge and Sundance Basin, than at Gore Turnout and Medicine Bow Curve. At Tombstone Ridge and Sundance Basin, numbers of dead or browsed terminal leaders were lowest, buds per live unbrowsed terminal leader were highest, and lengths of live unbrowsed terminal leaders were highest ($P < 0.05$). However, patch perimeter, percent dead, number of live unbrowsed terminal leaders, buds per dead or browsed terminal leader, lengths of dead or browsed terminal leaders, and total buds did not differ among sites having more or less ungulate pellet

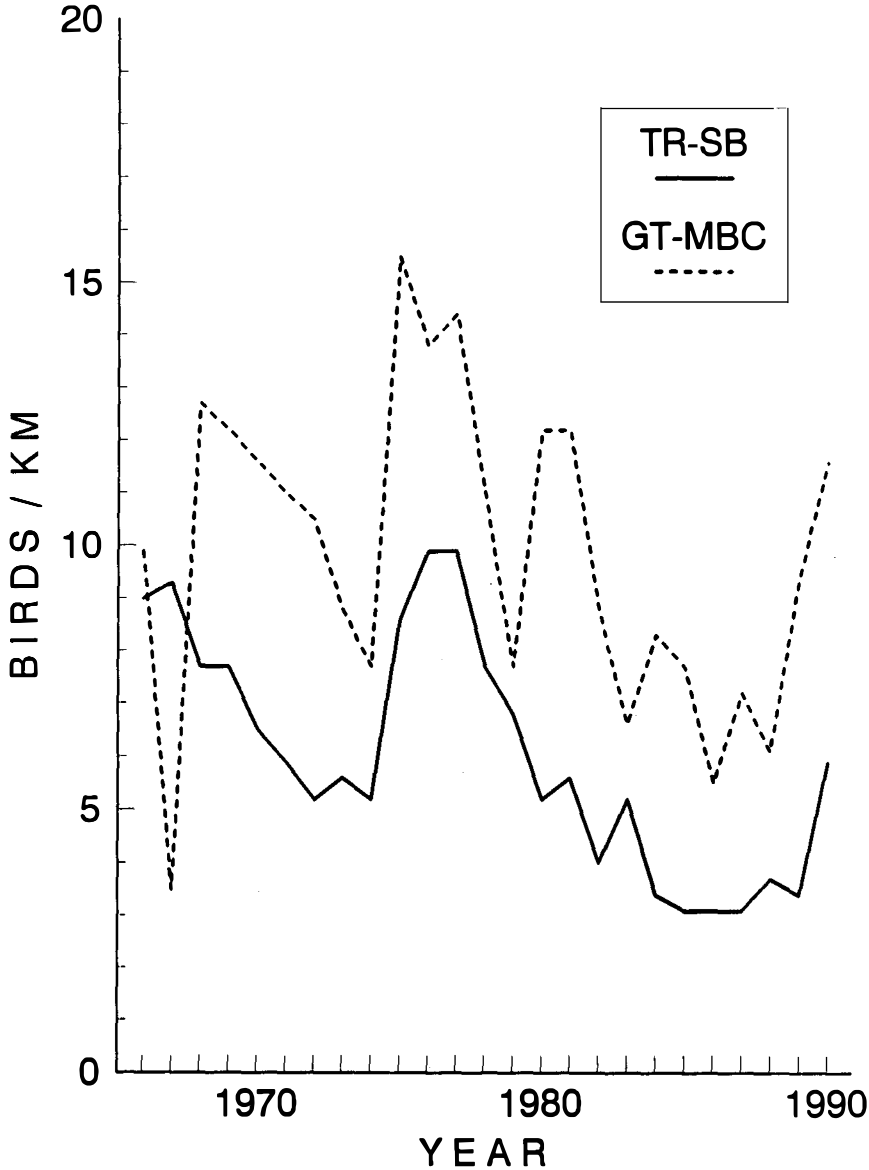

Figure 2. Trends in breeding densities of white-tailed ptarmigan at two study sites along Trail Ridge Road, Rocky Mountain National Park, 1966–90. (TR–SB = Tombstone Ridge-Sundance Basin, GT-MBC = Gore Turnout-Medicine Bow Curve).

frequencies ($P > 0.05$). Willow height was greatest when growing within or in the lee of dwarf conifers (*Abies lasiocarpa, Picea engelmannii*) ($P < 0.05$), but was not different among sites with higher or lower ungulate pellet frequencies.

Table 2. Canopy cover and frequency of key plant species on three transects in willow vegetation types on the alpine along Trail Ridge, Rocky Mountain National Park, 1971–89.

Category/species[a]	1971	1979	1984	1989
Salix brachycarpa	24/40[b]	22/40	24/44	19/41
Salix planifolia	25/51	19/54	19/52	17/52
Deschampsia caespitosa	27/90	18/76	23/84	24/79
Carex scopulorum	4/35	2/32	4/20	8/38
Anemone narcissiflora	6/21	5/22	6/20	3/19
Artemisia scopulorum	12/68	11/71	9/73	10/76
Caltha leptosepala	14/65	14/67	11/46	9/44
Geum rossii	25/86	23/87	24/89	20/89
Polygonum spp.	2/50	4/51	4/52	3/41
Potentilla spp.	6/53	4/41	3/27	4/41
Sedum rosea	4/46	3/40	2/48	2/23
Bare ground	1/10	1/5	2/21	1/13

[a]Taxa listed form at least a mean of 2 percent cover.
[b]Percentage canopy cover/mean frequency.

Table 3. Canopy cover and frequency of key plant species on four transects in krummholz subalpine willow types along Trail Ridge, Rocky Mountain National Park, 1971–89.

Category/species[a]	1971	1975	1979	1984	1989
Salix brachycarpa	20/38[b]	21/34	9/28	10/26	4/18
Salix planifolia	37/52	29/56	29/54	26/48	23/45
Vaccinium scoparium	14/46	15/40	12/48	10/40	7/34
Deschampsia caespitosa	11/38	11/33	16/44	16/47	20/56
Carex spp.	7/32	5/30	7/33	7/40	10/44
Poa spp.	3/23	2/24	5/44	4/35	2/19
Phleum alpinum	6/42	4/30	5/43	3/27	3/37
Arnica cordifolia	4/24	3/22	2/25	2/27	3/18
Aster spp.	7/35	3/32	6/60	5/43	2/26
Anemone narcissiflora	12/54	7/46	6/50	5/44	2/24
Delphinium barbeyi	5/34	1/11	4/33	1/13	tr/1
Senecio triangularis	2/18	1/11	3/19	4/18	4/7
Trollius laxus	2/28	4/41	2/31	3/14	2/36
Sedum spp.	2/22	1/18	1/21	--	1/6
Calamagrostis canadensis	3/12	3/24	9/36	4/14	8/36
Veronica wormskjoldii	4/44	2/12	1/24	4/31	4/43
Juncus spp.	1/8	1/6	1/13	2/13	2/15
Caltha leptosepala	3/14	2/16	2/23	2/23	3/7
Achillea lanulosa	2/13	1/13	2/15	4/14	4/19
Viola adunca	tr/6	tr/6	1/11	tr/1	2/27
Sibbaldia procumbens	tr/4	tr/2	tr/2	2/6	2/8
Bare ground	2/51	2/6	2/11	3/10	4/14

[a]Taxa listed form at least 2 percent cover in one year.
[b]Percentage canopy cover/percent frequency.

Discussion

Impacts of elk on willows in the alpine/subalpine are not fully understood. However, elk in Rocky Mountain National Park use willow extensively in winter; Harrington (1978:105–106) reported that "*Salix* comprised the greater part of the diet" and that elk had a "high preference for *Salix*." He also reported extensive use of nearly all *Salix* shoots by wintering elk and subsequent depression of vigor of *Salix* plants the following summer when *Salix* was in competition with grass-like plants. Hobbs et al. (1981) reported that willow comprised about 25 percent of elk diets in upper montane habitat during winter in Rocky Mountain National Park, possibly because willow diets were high in crude protein.

Our data on willow cover and frequency indicated that cover of willow in subalpine/alpine areas of Rocky Mountain National Park decreased from 1971 to 1989, a period when overall elk numbers within the park were increasing. Although feeding site analysis did not indicate willow was a major portion of the diet of elk in winter, data were not collected during the heavy use period in spring or fall nor in areas where willow was dominant or codominant. Therefore, data relating condition of willow to elk abundance are not strong. However, we still hypothesize that elk are at least partially responsible for the demonstrated decline in willow cover on the permanent transects.

Ungulate pellet frequencies were significantly greater at Sundance Basin and Tombstone Ridge, indicating that more elk may have spent more time at those sites when compared to Gore Turnout and Medicine Bow Curve. Surprisingly, numbers of dead or browsed terminal leaders were significantly lower at Sundance Basin and Tombstone Ridge. Numbers of buds per live unbrowsed terminal leader were significantly higher where ungulate pellet frequencies were higher. This may be the result of increased nutrient availability at those sites which encouraged more bud production when leaders were not browsed. Furthermore, if other parts of the plant were browsed, there may have been more energy available for bud production in undamaged parts of the plant. Live unbrowsed leader lengths were significantly greater where ungulate pellets were more frequent. Again, a combination of increased nutrient availability and browsing at those sites may have stimulated growth. In addition, a greater proportion of terminal leaders counted at Sundance Basin and Tombstone Ridge were primary leaders (adventitious shoots from below ground stock, possibly stimulated by browsing), which may grow at faster rates than secondary or tertiary (etc.) leaders. Greater willow heights were also found when willows grew within or in the lee of conifers. Conifers may protect willows from browsing by making them less accessible to elk and cause accumulations of snow, especially on their leeward sides, where willows could be protected from browsing until snowmelt.

Ptarmigan population data indicate that 7–10-year cycles may occur. If this hypothesis is true, the population should have been high in 1967–69, 1975–78, and 1985–88 (± 1–2 years). The population did increase in 1975–78 but decreased and remained at a relatively low level through 1989. We do not know if the increase in 1990 will continue for two to four years. If it does, the hypothesis that the population is cyclic remains possible. However, we presently hypothesize that heavy use of willow by elk in early winter and early spring constrains ptarmigan breeding densities by reducing amount of food (willow buds) available to ptarmigan in late winter during the early breeding period when ptarmigan establish territories (Schmidt 1988). Ptarmigan populations may still be cyclic but the duration and magnitude of oscillations may be lengthened or depressed excessively when their habitats are heavily used by elk.

These hypotheses, and that relating elk use to willow cover and height, remain to be tested. However, hypothesis testing frequently requires manipulative experiments (Romesburg 1981). Present National Park Service policy discourages manipulation or destructive experiments within parks. Approval of such experiments is the responsibility of individual superintendents who may not have long term views. Thus, there are research and management dilemmas in national parks.

The first dilemma of management is: in light of man's activities in and around the park, what constitutes a natural functioning ecosystem? The primary question is whether the abundance of elk is within the normal variation of natural ecosystems in Rocky Mountain National Park. If downward changes in vegetation, as well as in the ptarmigan population can be determined to be ''natural'', then any management action is unwarranted. This is true even if the large elk population is adversely affecting its own habitat and, eventually, negatively affects populations of other native flora and fauna, or the overall biodiversity of the park. What criteria do we use to make this determination? This appears to call for far more insight into the functioning of natural ecosystems than is presently available.

Another dilemma lies in our inability to collect data necessary to make this determination. It appears the answers to our present questions may be limited by restrictions placed on conducting experimental research. Therefore, another dilemma is, what level of manipulative or disruptive research should be allowed in national parks to generate valid data to identify causes and effects? Does the end justify the means? Should the aesthetic value of a certain resource be compromised to learn the true relationships that may answer the question; remembering that Trail Ridge is observed by more than 2.5 million visitors each year.

This leads to a third dilemma: how do you manipulate a migratory elk population in an alpine environment while allowing the remainder of the ecosystem to function naturally? At least part of the answer is further research. We must design studies that will provide information to managers necessary to ascertain the ''naturalness'' of the ecosystem. These projects need to be designed without compromising the visitors' experience in the park. If possible, human-caused perturbations must be isolated and managed first. We must do a better job of mitigating the impacts of park visitors and neighbors. Then, populations or processes that will least effect the overall ecosystem need to receive research and management attention through well designed experiments that test meaningful hypotheses.

Acknowledgments

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Denali Park Wolf Studies: Implications for Yellowstone

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Introduction

The Northern Rocky Mountain Wolf Recovery Plan approved by the U.S. Fish and Wildlife Service (1987) recommends re-establishment of wolves (*Canis lupus*) in Yellowstone National Park. Bills proposing wolf re-establishment in the Park have been introduced into the U.S. House and Senate. However, several questions have been raised about the possible effects of wolf re-establishment on other Yellowstone Park fauna, on human use of the Park and on human use of surrounding areas. Thus the proposed wolf re-establishment remains controversial.

Information pertinent to some of the above questions is available from a current study of wolf ecology in Denali National Park and Preserve, Alaska, which we began in 1986. Although Denali Park differs from Yellowstone in several ways, it is also similar enough in important respects to provide insight into questions raised about wolf re-establishment in Yellowstone.

Both Denali and Yellowstone are vast, multi-predator/multi-prey ecosystems with large herds of ungulates protected from hunting. Yellowstone Park itself covers some 3,472 square miles (8,888 sq km) and is surrounded by public wilderness encompassing several times that area. Denali includes about 7,000 square miles (17,920 sq km) of park and an apron of 2,000 square miles (5,120 sq km) of designated preserve.

Denali is home to some 2,000 moose (*Alces alces*) (Meier 1987), 3,000–4,000 caribou (*Rangifer tarandus*), including those adjacent to the park that are within range of park packs (L. G. Adams personal communication:1990), and 2,000 Dall sheep (*Ovis dalli*). Yellowstone supports an estimated 22,000 elk (*Cervus elaphus*) in winter and more in summer, 3,000 mule deer (*Odocoileus hemionus*) (Singer 1988), 2,700 bison (*Bison bison*) (Bishop 1989), and smaller numbers of other ungulates.

Grizzly bears (*Ursus arctos*), black bears (*U. americanus*) and coyotes (*Canis latrans*) inhabit Yellowstone and Denali, and compete in varying degrees with wolves for ungulate prey.

Furthermore, both parks are well-known and heavily visited by the public, most of whom are particularly interested in viewing wildlife. Broad vistas are features of Denali and Yellowstone alike, and they greatly facilitate wildlife observation.

During the public debate about whether wolves should be restored to Yellowstone, the following questions are among those that have arisen: (1) would wolves decimate Yellowstone's elk, moose and bison? (2) would wolves jeopardize the park's grizzly bear population? (3) would wolves threaten human safety? (4) would large areas of Yellowstone need to be closed to protect wolves? (5) how many wolves would Yellowstone support? Since 1986, we have radio-collared 76 wolves in 14 packs in Denali, and have aerially radio-tracked them and their packmates approximately weekly, yielding 42 pack-years of data. Through 1989, we located radioed wolves 3,648 times and observed them and their packmates almost 3,000 times, including when they were traveling, hunting, feeding, attending dens and rendezvous sites, and dispersing. We also collected data on over 300 ungulates that the radioed packs killed.

Denali Findings Pertinent to Yellowstone

As with most wolf populations, the Denali wolves live in packs occupying exclusive territories (Figure 1). Pack sizes vary from the basic breeding pair up to a maximum of 27, but average about 9 during winter. Minimal estimates of their territory sizes range from 133 to 1,693 square miles (340–4,335 sq km), and average 463 square miles (1,184 sq km). Mean number of pups per pack surviving to winter was 2.0 in 1986, 2.4 in 1987, 5.1 in 1988, 4.0 in 1989 and 5.6 in 1990.

The wolf population appears to have been increasing throughout the study, and the density now has reached about one wolf per 39 square miles (100 sq km) for a total population of about 173 wolves in the habitable part of the park and preserve. Wolf numbers in the area are limited by intraspecific strife and dispersal. Of 59 radioed wolves whose fates were known, 20 percent were wolf-killed, 17 percent dispersed and 53 percent remain in the study area. Of 12 wolves radio-tagged in 1986 and whose fates are known, 33 percent have been killed by other wolves, 42 percent have dispersed and 17 percent remained in the population three years later, and one was killed by humans.

When wolves disperse from Denali, we do not follow them because of the great expense involved. However, indications are that generally the characteristics of wolf dispersal from Denali are similar to those of wolf dispersal elsewhere. Many dispersed wolves travel great distances and in every direction (Mech 1987). Denali dispersers that were killed by humans outside the park and reported to us have ended up as far as 250 miles (400 km) from the park and have gone in all directions.

Denali's wolves prey on all three of the park's ungulates. Because of observation bias—for example, moose carcasses last longer and are easier to see than are sheep carcasses—we have been unable to determine whether wolves are preying disproportionately on any particular prey species. Of 306 kills examined, 52 percent were moose, 34 percent caribou and 14 percent Dall sheep. Even considering the biases, however, these figures indicate that all three prey species are important to the wolves.

As in other areas, wolves in Denali tend to take certain prey disproportionately: young-of-the-year, old animals, males just before, during and after the rut (when rundown and undernourished), and individuals debilitated by arthritis and other conditions.

There is no indication that wolves are limiting prey populations in Denali at present. In fact, caribou are increasing (L. G. Adams personal communication:1990) as wolf numbers rise. This situation is reminiscent of the Isle Royale National Park ecosystem

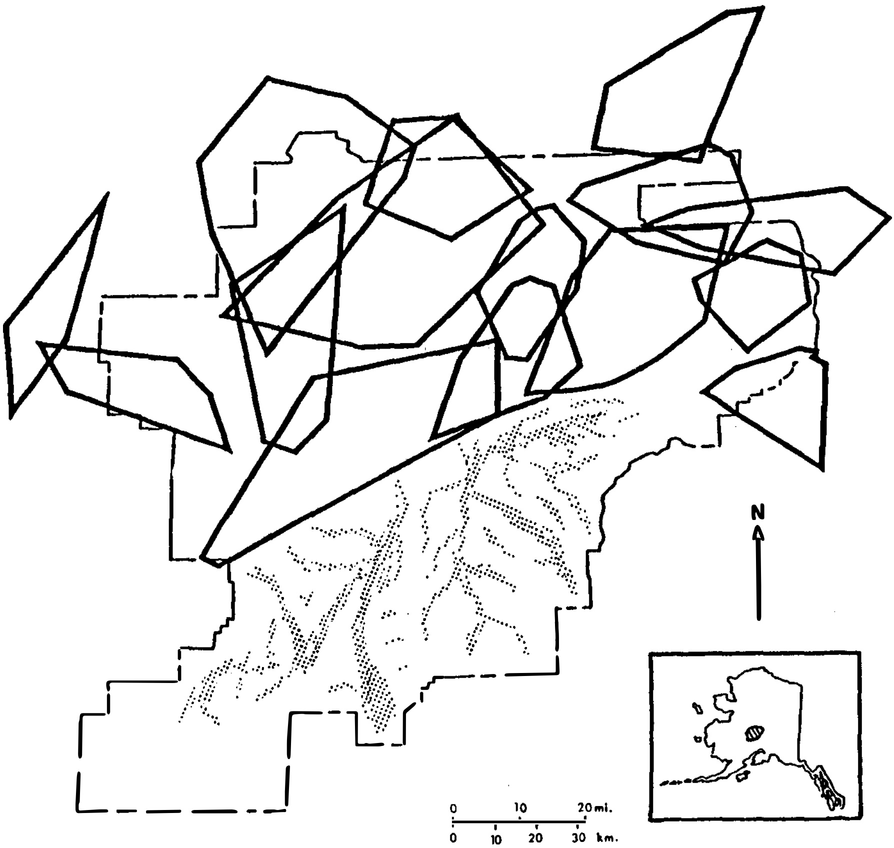

Figure 1. Wolf pack territories in Denali National Park as of 1989. Mountainous and glacial areas along southeast side of park are devoid of wolves and prey.

in which moose twice tripled their numbers in the face of a protected wolf population (Peterson and Page 1988, R. O. Peterson personal communication: 1990).

Wolf interactions with grizzly bears may take several forms. Members of each species might kill members of the other; each might try to usurp kills of the other; and each might compete with the other for the basic food supply. That grizzlies kill and eat the same prey as wolves is well documented, and we have records of members of each species chasing the other off kills, and of each attacking the other.

Although generally wolves and grizzlies try to avoid each other, when they do encounter one another, the grizzly usually dominates, for example around kills. On the other hand, wolves occasionally kill grizzly cubs. Nevertheless, there is no evidence that the net result of wolf/grizzly interactions is of any consequence to either population.

The remaining issues on which the Denali study can lend insight to wolf reestablishment in Yellowstone regard wolf/human interactions. There has been some worry that, if wolves were reestablished in Yellowstone, large areas of the park would have to be closed to prevent disturbance of wolves around dens and rendezvous sites.

Like coyotes and foxes (*Vulpes* spp.), wolves only use dens for about eight weeks in spring when they bear and raise their pups. Pups are born in May, and during the pups' first three weeks, they cannot maintain their own body heat. Thus they must be protected closely by the alpha female, who lies with them most of the time in the den.

Wolves sometimes will abandon a den if greatly disturbed by humans. They then transport the pups by mouth to an alternate den, and during the process the pups would be exposed to the air and any inclement weather. They might also be lost if the adults had to cross swollen rivers. We know of no records of such losses, and according to Chapman (1977:101) who summarized available data from many studies, "Pup mortality as a result of human disturbance has never been reported." Furthermore, we have documented the safe transport of pups about 10 days old from two litters for distances of about 1.2 miles (2 km) between dens, which supports data from several other studies (Chapman 1977, 1979). Nevertheless, the chances of mortality certainly must increase if pups are transported at an early age.

Therefore, it seems reasonable that in national parks some measure of protection should be afforded wolf dens before, and during at least the first four weeks after, the pups are born. Chapman (1977, 1979) found that in open country wolves were usually not disturbed by observers farther away than 0.5 mile (0.8 km). To be conservative, he recommended that an area within a radius of 1.5 miles (2.4 km) around the den be closed to human travel from about one month before denning until about three months after denning begins.

However, since Chapman (1977, 1979) completed his study, many more observations have been made that imply that at least in national parks, protection of wolf dens can be much less restrictive. For example, in 1990, a female wolf raised a litter of pups within 200 yards (200 m) of the road in Denali. Eventually she brought the pups out onto the road, much to the delight of the busloads of tourists who photographed them.

There still remains no record of wolf pups losts because of disturbance by humans. Therefore the only closures that might be necessary in Yellowstone would be areas of about 1 mile (1.6 km) radius around dens for about one month before denning to two months after, approximately March 15 to June 15. This is before the main tourism or backpacking season.

Regarding the contention that wolves are dangerous to humans, that can be dismissed as merely a popular misconception. Certainly any large carnivore, including even dogs and coyotes, should be viewed cautiously around children (Carbyn 1989), but the wolf's record is remarkably clean (Mech 1990).

Public Benefits of Wolves

Rather than being a danger to humans, the wolf should be regarded as a major tourist attraction. In Algonquin Provincial Park, Ontario and the Superior National Forest of Minnesota, throngs of tourists join evening trips to howl to wolves and listen for their responses.

In the latter area, several "aerial wolf safaris" are held each winter for members of the public to observe wolves on frozen lakes from aircraft, and the trips are usually fully subscribed. Throughout most wolf range, the animals are so shy and secretive they can only be seen from the air. However, where they have been protected, such as in Denali, they are observable from the ground, and there they constitute one of the main attractions of the park.

Yellowstone could also boast the wolf as one of its foremost features. With its great herds of ungulates roaming open flats and valleys, the park would eventually see its wolves patrolling the same areas picking off prey in full view of the human visitors. That happens regularly in Denali, where an estimated 15 percent of the tourists observe wolves.

Conclusions

These are the lessons of Denali. If heeded, they should reassure authorities that restoring the wolf to its previous place as Yellowstone's top carnivore will not decimate the prey herds or the grizzly; it will not require closing of the park; and it will not scare away the tourists. Instead, the return of the wolf will herald a new era in which visitors to the nation's foremost national park will be treated to a more realistic view of how natural predator/prey systems operate.

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Public Attitudes in Wyoming, Montana and Idaho Toward Wolf Restoration in Yellowstone National Park

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Introduction

The proposal to restore wolves into Yellowstone National Park has been discussed at scientific meetings, within government agencies and at public meetings for the past several years. Much biological information has been gathered concerning the impacts and effects of restored wolves since the Northern Rocky Mountain Wolf Recovery Plan (U.S. Fish and Wildlife Service 1986) was first released. Recently, another report documenting biological impacts of wolves on Yellowstone's prey base, impacts on the bear population, and wolf management zones was presented to the United States Congress (Yellowstone National Park et al. 1990). Although other biological data exist about the wolf (Fritts and Mech 1981, Weaver 1978, Van Ballenberghe et al. 1975, Mech 1970, Pimlott 1969), the wolf restoration issue does not appear to be proceeding (either towards a positive or negative decision) as perhaps it could. Such biological information is necessary to understanding the wolf restoration issue, but putting wolves back in Yellowstone National Park is not as much a biological issue as a sociopolitical one (Bath 1989).

Leopold (1930) noted that people are the most important variable in the wildlife management equation. This could not be more true today with controversial wildife programs, like the proposed wolf restoration. Implementing such programs requires information about the public for whom those wildlife are managed (Bath and Buchanan 1989). A need exists for an understanding of public attitudes toward the proposed wolf restoration in Yellowstone National Park. The wolf issue still lacks this critical information on the human element of the wildlife management equation.

Nationwide data suggests the U.S. public likes the wolf and within the Rocky Mountain region 50 percent like the wolf while 30 percent dislike the animal (Kellert 1985). Visitors to the park also overwhelmingly support wolf restoration (McNaught 1985, Bath 1990). It is not known what attitudes exist toward the issue from residents of the immediate area around the park. It is important to identify and document these regional viewpoints. The states directly around the park (Montana, Idaho and Wyoming) stand to be most affected by the proposed wolf restoration. In 1987, a statewide survey of the Wyoming general public (N = 371) randomly selected, revealed that most Wyoming residents (48.5 percent) favored wolf restoration while 34.5% percent were opposed and 17 percent had no opinion (Bath 1987a, Bath 1987b, Bath 1989, Bath and Buchanan 1989).

However, 3 percent and 1 percent of the park are located in Montana and Idaho, respectively. In an effort to involve the general public in these two states in the decision-making process, statewide surveys, identical to the Wyoming study (Bath

1987a, Bath 1987b), were mailed to randomly selected residents of Montana and Idaho. The ultimate decision of wolf restoration lies with the agencies involved. However, implementation of any program of wolf recovery would be facilitated by addressing the concerns of the public in the three state area. The purpose of this research was to assess the degree to which three variables—attitude toward the wolf, willingness to restore the wolf, and knowledge about the wolf—could be used to discriminate among three general public statewide samples (Montana, Idaho and Wyoming) involved in the restoration issue.

Methods

Data were collected in 1987 through mail surveys, randomly choosing one sample (n = 371) of the Wyoming general public proportional to county population from telephone directories. In 1990, data were collected using the identical research instrument and mail survey methods, randomly choosing one sample (n = 672) of the Montana general public and one sample (n = 618) of the Idaho general public. Standard survey techniques were followed (Dillman 1978). The survey included a cover letter and a return self-addressed stamped envelope. Two postcard follow-ups and two additional mailings of the survey were required to increase response rate.

The survey consisted of questions regarding attitudes and knowledge about the wolf and the restoration issue. Attitude scores were computed by adding and averaging responses from the eight attitudinal items, using a five point Likert response format from "strongly agree" to "strongly disagree." Scale reliability (Carmine and Zeller 1979) was assessed with Cronbach's alpha for the ordinally scaled attitudinal items, which produced a reliability estimate of 0.94. Knowledge scores were computed by adding the number of correct responses from the 15 knowledge items and assigning one point for a correct response and zero points for incorrect and "I don't know" responses. Kuder Richardson Formula (KR20) was used to assess the reliability for the dichotomously coded knowledge items, which produced a reliability estimate of 0.82. A reliability estimate of 0.60 was established as acceptable (Nunnally 1970).

Analysis of variance was used to profile the degree of difference among the three groups for attitude toward the wolf, knowledge about the wolf, and willingness to restore the wolf. Tukey's HSD post-hoc procedure allowed the identification of which specific groups were significantly different (Lutz 1983). A significant level of $p = 0.05$ was used.

Results

The response rate for the survey was 61 percent for Montana, 57 percent for Idaho and 48 percent for Wyoming. Responses to each attitudinal item revealed different views about wolves (Table 1); however, most respondents, from all three states, had positive mean scores across all the attitudinal items. The analysis of variance did reveal significant differences ($F = 5.908$; $p = 0.003$) among the three groups across the attitude toward wolf score (Table 2). Tukey's HSD post-hoc tests indicated that Idaho residents had the most positive mean attitude toward the wolf score and Montana residents had the least positive score. Wyoming residents had a significantly more positive attitude score than Montana residents.

Table 1. Responses (percentage) to selected attitudinal statements[a] about wolf restoration in Yellowstone National Park, as determined by a survey of Wyoming, Montana and Idaho residents.

Survey group	Strongly agree	Agree	Neither	Disagree	Strongly disagree
Which answer best describes your attitude toward the wolf?"					
Montana	15.3	29.4	33.0	8.7	13.6
Idaho	18.9	34.4	34.8	6.4	5.5
Wyoming	18.1	29.1	33.2	7.5	8.1
"Wolves reintroduced into Yellowstone National Park would cause more damage to livestock than wolves presently do in Minnesota livestock range."					
Montana	7.5	19.2	29.6	34.0	9.8
Idaho	5.1	11.1	37.2	35.5	11.1
Wyoming	6.7	12.7	32.2	34.8	11.6
"If reintroduced wolves killed livestock, the problem wolf should be killed."					
Montana	26.3	33.7	10.5	21.3	8.2
Idaho	16.0	32.9	14.1	27.3	9.7
Wyoming	20.2	38.3	9.4	21.6	8.1
"The monetary costs of reintroducing the wolf will exceed any benefits gained by having the wolf in the park."					
Montana	20.7	24.1	19.6	23.8	12.0
Idaho	10.8	20.5	22.7	34.2	11.8
Wyoming	18.1	18.6	27.8	23.7	9.4

[a]Other statements from questionnaire:
Because healthy populations of wolves exist in Canada and Alaska, there is no need to have wolves in YNP.
Wolves would deplete elk numbers to unnacceptable levels in YNP.
Wolves would have a significant impact on big game hunting opportunities near YNP.
Wolves would be a significant predator on the livestock industry around YNP.

A descriptive summary of knowledge score results indicated that all groups received low mean scores, indicative of less than half the questions answered correctly. No significant differences ($F = 2.944$, $p = 0.053$) were found between the three groups (Table 2).

All three statewide samples supported wolf restoration into Yellowstone National Park. Most Wyoming residents (48.5 percent) favored wolf restoration while 34.5 percent were opposed and 17 percent had no opinion. 56 percent of Idaho residents

Table 2. Results of analysis of variance across Wyoming, Montana and Idaho general publics on attitude toward the wolf, wolf knowledge score and willingness to reintroduce the wolf.

Variable	Wyoming	Montana	Idaho	Significance
Attitude toward the wolf[a]	3.19	3.12	3.33	$p = 0.003$
Wolf knowledge[b]	5.59	6.07	5.72	$p = 0.053$
Willingness to reintroduce[c]	0.60	0.56	0.66	$p = 0.002$

[a]Attitude scores range from 1 (strongly dislike) to 5 (strongly like).
[b]Knowledge scores range from 0 (no questions answered correctly) to 15 (all questions answered correctly).
[c]Willingness to reintroduce scores range from 0 (not in favor) to 1 (yes, in favor of wolf restoration).

favored wolf reintroduction while 27 percent were opposed and 17 percent had no opinion. Most Montana residents (43.7 percent) also favored wolf restoration but 40.3 percent were opposed and 16 percent had no opinion. Analysis of variance indicated that significant differences ($F = 6.254$, $p = 0.002$) in willingness to restore the wolf existed between groups (Table 2). Idaho residents were more in favor than both groups. Wyoming residents were more in favor than Montana residents.

Discussion

This study—documenting Montana, Idaho and Wyoming public attitudes toward the wolf restoration issue—offers resource managers, politicians and all those involved in decision-making process the complete regional perspective on this issue. Such human dimensions in wildlife resources research are central to the task of public involvement in complex, controversial wildlife programs. In addition, this research can help monitor changes in attitude toward the wolf and knowledge about the wolf. In turn, this information could be used to assess education efforts and changes in the development of the wolf restoration issue. This approach of documenting representative samples of the general public in each state surrounding Yellowstone National Park is useful to resource managers in making sure that highly vocal lobby groups are not overrepresented in the decision-making process (Bath 1989).

Overwhelming support exists from park visitors to restore wolves to Yellowstone National Park (McNaught 1985). Recent data, collected through 1989–1990 of random visitors to the park, also support wolf restoration (Bath 1990). It has been argued that support for wolf restoration only exists from park visitors and those who live in other parts of the United States, not in the west. Even if this was true, with Yellowstone National Park being the first U.S. national park, it may be pertinent to consider the viewpoints of the entire nation on this issue. It is however important to understand the attitudes and concerns of the residents of the immediate area.

This study documents that most Wyoming residents (48.5 percent), most Idaho residents (56.0 percent), and most Montana residents (43.6 percent) all support wolf restoration. In addition to this human dimension in the wildlife management equation indicating clearly support for wolf restoration, recent biological studies suggest healthy populations of wolves can exist in the park (Boyce 1990, Fritts 1990, Singer 1990, Yellowstone National Park 1990). Resource managers that want to manage wildlife resources for their entire constituency and politicians who wish to accurately represent the opinions of their respective states, can move forward positively toward wolf restoration knowing that they have a majority of public support from Yellowstone visitors, Montana, Idaho and Wyoming residents, and sound biological data for their decision.

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Closing Remarks

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I want to thank the speakers for their excellent presentations, and especially Dr. Joubert, for coming this great distance to share his experiences with us. I extend appreciation to the audience for its attentiveness and responses, and to Cliff Martinka for doing such a great job in moderating the discussions.

This session has been one part of an on-going Wildlife Society study of wildlife management policies in national parks, and was assigned by The Wildlife Society. Consequently, the papers were chosen by Cliff and me because of their relevance to different aspects of national park policy. I should say that the comments which follow are my inferences from the papers we have heard, and do not necessarily reflect the views of other committee members involved in the Society study, or of Cliff.

Although biologically and geographically diverse, there are recurring themes in these papers and a logical thread that binds them together. The first theme, articulated by most of the speakers, but focused on by Underwood and Porter, sampled by Bath and implied by Mech et al., is that policies are driven by social values. There is general agreement that society needs areas of natural biota, ideally with minimal disturbance by technological man, to serve as scientific, educational, historic and aesthetic reference points for the structure and function of ecological systems. There is a need to sharpen some of the concepts and rhetoric surrounding this value, but there is virtually no disagreement on the general idea, and national parks are widely looked to for serving this value.

It is over the means for serving this value that disagreement arises, and this disagreement tends to sort itself into two schools of policy thought. I will call one the *laissez faire* school which holds that park ecosystems should be left alone without human intervention to function as much as possible like they might if there had been no European influence. The argument against this approach by the second school, which I will call the interventionist school, is that these systems are so changed that they are unlikely to function as they would without prior European influence, and must be assisted to do so with advertent management. What light have the papers today shed on this dilemma?

Most of the papers have pointed out that virtually no parks are free of external, human influences. Fuller, Cornelius, and Ogden and Johnson have given us extreme examples of this. Moreover, virtually no parks contain the full complement of flora and fauna that prevailed prior to European arrival. And I emphasize that this includes the effects of indigenous, subsistence human cultures. We ecologists commonly discount this effect, but Warren has forcefully pointed it out to us; and anthropologists and archaeologists worldwide are increasingly pressing it upon our ecological consciousness. If Kruger National Park, some 2.5 times as large as Yellowstone, is not free of outside influence and is not a self-contained biota, then one has to wonder if any parks in the world can be.

Critics of *laissez faire* hold that we should not delude ourselves into thinking that these systems will function as they did in pre-European times. We should, in their view, use our collective scientific understanding to predict where these variously diminished and externally influenced systems are likely to go if not given thoughtful intervention. And they maintain that we should concede the distinct risk that these systems may alter themselves to the point where they no longer resemble the ''natural'' or ''pristine'' or ''healthy'' systems that are the main value which society looks to the parks to serve. Moreover, we should, in their view, be up front with the public about the reality of this risk.

It is clear from Joubert's presentation, that the National Parks Board of South Africa has chosen not to accept this risk, and Warren has urged us North Americans not to accept it. The evidence presented by Braun et al., and by Warren, suggests that the answer to the question is at hand.

The second school of thought holds that it takes scientifically enlightened, judicious and courageous management action to compensate for external pressures and historical changes to allow these systems to function in some approximation of pre-European circumstances. This is the approach urged by the Leopold Committee in 1963 and the Gordon Commission in 1989, and the one Joubert has described for us today. Or it may take heroic efforts, like Ogden and Johnson have described for the Everglades, to restore significantly altered systems. This, again, is what the Leopold Committee advocated in 1963.

The intervention approach too has its risks, and intervention critics fairly point to fiascos of the past like those described by Cliff Martinka at the beginning of this session. But interventionists reply that ecological science has made great strides in recent decades. And applied ecology has matured in the forms of modern forestry, range management and wildlife management. A new Society for Ecological Restoration exchanges scientific information in its journal on restoring disturbed ecosystems. The Ecological Society of America publishes a new journal, *Ecological Applications,* which devotes its pages to articles on the application of ecological principles to environmental protection and natural-resources management.

So resolution of the dilemma becomes a matter of weighing the risks of letting altered systems irreparably distort themselves against the risks of applying imperfect, but ever more sophisticated, scientific understanding. I, for one, am appreciative each time I have an ache or pain, that medical science did not throw in the towel in the 1800s because it was losing too many patients. But now I insert my own values into the discussion, and Underwood and Porter tell us that I should avoid this if I am to retain my credibility as a scientist. In fact, I hold that because policies are set to serve social values, it is society and not us professionals which should exercise the option between the two horns of this dilemma.

A final word about science. Underwood and Porter have cautioned us about intertwining values and policy with science. There is a danger for science in letting the two get too close. Science, in their view, should indeed illuminate the policy process. But there is a need for safeguards against letting values and policy implications color scientific inference. And in listening to Braun et al. discuss constraints on research, I can only conclude that a policy which prevents the acquisition of data needed to design a management program for protecting a valuable ecosystem must bear the onus if that system irrevocably damages itself.

Special Session 2. *Generating Information for Fish and Wildlife Management*

Chair
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Opening Remarks

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Welcome to Special Session 2 of the 56th North American Wildlife and Natural Resources Conference. We are delighted that you have chosen this session. I am sure this session will generate ideas and stimulate discussions about the fish and wildlife information you are managing—such as how the information is being used, and who cares! Is the information you are generating a renewable or non-renewable resource?

We plan to address this question during the next two hours. Reflect for a moment on the past 50 years (1940–1990) in fish and wildlife organizations, i.e., factors influencing information generation, use and abuse: wildlife management was established as a science; national legislation, such as Pittman-Robertson was passed; the first national assessment of wildlife resources (1936–1940) was completed; three world wars/conflicts and most recently a fourth in the Persian Gulf; space-age technology; computer-age technology; population explosion/baby boom; TV, VCR/video, stereo/compact disc; electricity; indoor plumbing; high-speed transportation, including interstate road systems for automobiles, and air travel; training facilities; fast food; disposable everything; EIA/EIS; threatened and endangered species; pollution, earthday; recycling; etc.

Specifically, let's look at fish and wildlife information. In 1940, it was meager—a few books, a few technical journals, a couple hundred scientists with horses, a few autos, pens, pads and cameras.

1990— what has happened? What have we learned?

- We are generating large quantities of fish and wildlife information.
- We have tremendous computer technology.
- We have more facilities, technology, information and personnel than at any

other time in history. How have our answers changed to the questions raised in the opening remarks of the 44th North American Conference (1979) such as:

- How many species of animals do we have at county, state, national or continental levels?
- What do these animals require and how much of what they require is available? Where is the habitat located? How do animals and habitat respond to alternative uses?
- What are the goals and objectives for fish and wildlife programs at different levels?

My assessment is that we are polluting ourselves with large quantities of information that we do not manage, recycle or share.

This session is designed to look at what has happened during the past decade and chart a course for the decade of the 90s that will help us increase our efficiency in management of the fish and wildlife information resources.

Computer Data Usage in Wildlife-related College and University Programs

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There are so many diverse wildlife conservation, management and science curricula in the U.S. and elsewhere that it is difficult to decide upon and describe computer use within them. For example, computers are widely used in forestry programs (e.g., Hitchcock and Foster 1983, Jungst and Colletti 1980, Pelz 1978, Pelz and Ware 1978, Schomaker and Mitchell 1976), but all wildlife curricula do not include forestry courses or those forestry courses employing computers. Statistics, basic biology, botany and ecology computer programs now are widely available for *all* university students, both on mainframe and microcomputers. Should they be listed as computer use in wildlife curricula? Should a course in computer programming (perhaps learning how to use some language like Pascal or C) be included if no computer programs are used elsewhere in the entire curriculum?

Let it be understood that computer use in the wildlife education arena has a long history. I began use in Idaho about the time that Dean and Gallaway (1965) published their computer article. Benson (1964) discussed computer use. Several fisheries workers were already using mainframe computers in their courses (Titlow and Lackey 1972, Lackey 1975) when Suppes (1966) was writing about the impact that computers might have on education. Computers have been used in fishery and wildlife research much before that—the late 1950s—and since findings from such use entered the classrooms of the professor's doing such work, it can be said that computers were being used in the wildlife program. Programmable electronic calculators, "computers," were used in biology (Spain 1971) for simulation.

In 1971, a questionnaire was sent to 72 institutions of the National Association of State Universities and Land Grant Colleges asking if they used computers in instruction. There was use in 123 courses in agricultural engineering, 110 in resource economics. There were 45 courses, each having use in animal science, genetics and statistics. There were computers used in 39 courses in forestry, range, wildlife management and conservation (Folks et al. 1972).

Festa (1983) got good returns from a questionnaire and found 96 percent of all fisheries agencies use computers. Microcomputers were then used in 50 percent of the agencies. Uses included analyses of research study data, analysis of harvest data, budgeting and field survey data storage.

McElroy (1983), in the same year, published a world list of fishery programs. He quoted L. C. Anderson who observed "there already appear to be more programs available than are actually used." Fisheries educators (1983) had a session on computer use in education.

A study is not needed to realize that computer use is abundant in graduate wildlife programs. The presence of computers in schools of the nation more than double each year (Bork 1984). In some universities (e.g., Drexel [Bork 1984]), all students are required to purchase a personal computer. In my university, all engineering students must do so (but not *yet* all students of wildlife resource management). Diesslin (1981) described Indiana's computer delivery system but seemed premature in his expectations as have others (Giles 1967). Students use a wide variety of statistical packages and programs to analyze their data. The spate of textbooks in this area (Green 1979, Berryman 1981, Moen and Moen 1985, Grant 1986, Starfield and Bleloch 1986, Schwartzman and Kaluzny 1987, Ludwig and Reynolds 1988), suggests publishers are aware of student/professor/practitioner markets for such books.

There are courses in population dynamics and some in population estimation that use a variety of software—some local, some freeware, some commercial (e.g., Jacquez and Ginzburg 1989). Many of these courses are in mathematics, statistics and biology units of universities and are available to advanced wildlife students.

Survey

In 1990, I conducted an informal telephone interview of select faculty in major wildlife programs throughout the U.S. and state wildlife agencies, and mailed a request for information to 30 people that had ordered wildlife computer programs. Throughout the conversations there was general awareness of computer use within the universities or colleges, general awareness of use of statistical software for research by graduate students, widespread use of word processors, and reports of a few places where computers were used in classes on population or habitat analyses. Based on this brief survey, there appears to be very little computer use in the wildlife curricula of North America or by wildlife professors. The amount of use is obviously a relative statement because for use levels may be compared to the past or to the potential. As Drew (1989:12) asked, "should be simply wait for the old fogies who became tenured in that primitive precomputer era to retire?" As he answered his own question, the questions, as well as answers, are more complicated than that.

The limitations to computer use described later suggest some of the reasons why there is no greater use. Drew (1989) stressed genuine limits in aptitude and interest. Many professors prefer to work with theory, principles and concepts, and, while they usually employ examples in their lectures, these are simple and brief to expedite progress within the course of study. Others work in rapidly changing fields so that any computer programs, except those having data processing (or similar) functions, are quickly dated or need revision. In the wildlife area, markets seem limited so programs available are not readily commercialized, reducing some incentive. Thus, there is little motivation to create such programs. Hardware, funds and space remain obstacles to in-class use but alternatives exist such as personal computers for out-of-class use and new projection equipment for computer results in class.

The Educational System

The realm of computers in wildlife university education now is so large that emphasis can be misplaced if it is only on computer programs or data. Computer-aided educational systems, no longer prototypes or prognostications (e.g., Giles 1967) now include:

- word processors to write term papers and assignments;

- grammar aids and writing improvement programs with thesaurus and spell checking;
- computer-backed dictionaries and encyclopedias (e.g., *Oxford English Dictionary* on CD-ROM, Oxford Electronic Pub., N.Y.);
- desk-top publishing for final reports by individual students or for class notes;
- student note files and personal information storage (e.g., askSam or Paradox [Slatta 1986]);
- access in more than 10 states to computerized wildlife data bases;
- automated main academic library search programs (e.g., VTLS, Blacksburg, VA.);
- student hand-held scanners for text or data (input devices);
- program languages and computing aids at educational cut-rate prices;
- program and test-authoring systems (Winn 1987);
- a large set of general purpose programs such as spreadsheets (Graham 1987, Silvert 1984);
- resources for liberal education (Johnson 1981);
- a large resource of wildlife-specific educational units, programs or systems;
- expert systems that allow selection of appropriate tests or material (e.g., Statistical Navigator);
- classroom presentation programs (Hofstetter 1989);
- automated test and quiz development (using random access to a base of questions (Dolphin et al. 1973);
- automated grading of mark-sensed answer sheets;
- automated grading and class analysis systems (e.g., Gradekeeper-PC (Bell 1983, Dolphin et al. 1973);
- scheduling of classes and use of facilities and other administrative work;
- user and special software groups for support and ideas; and
- varieties of use in continuing education (e.g., Scanlan 1986).

There are few users of computerized fish and wildlife information systems within universities, but the potentials are large and include:

- topics for term papers or species background for reports;
- simulations of effects of land-use change (mature forest to recently harvested forest) on wildlife;
- similarity and diversity analyses;
- campus and project-area checklists (e.g., for ornithology classes);
- assigning a permanent storage place for all relevant field data collections on fauna;
- studies of hypothesized impacts (e.g., due to change in stream pH);
- bibliographies and library searching aids;
- data for geographic information system analyses;
- suggestions for experiments and research (to help fill in the blank); and
- creation of farm and land-use plans, particularly using CAD technology, and development of other graphics for watersheds, etc., (Kesler and Smyser 1986, see *Computer Graphics Review* 80 page 1989 directory).

Often overlooked, the role of the computer as a thing to be taught (the tutee) can be important. Teaching is widely reported as an excellent way to learn. By allowing or requiring the student to teach, learning may be improved. Programming requires mastery of a topic. By it, a programmer may teach the machine (1) to do something or (2) to teach another person to do something (Taylor 1983).

Purposes and Advantages

The purposes of the use of computer programs in instruction throughout the university have included:

- making empirical estimation in economic relationships;
- conducting genetic experiments impossible in class or laboratories;
- analyzing complex plant/environment relations;
- becoming aware of effects of using inaccurate or limited data;
- becoming aware of the complexity of bio-physical systems;
- visualizing soil/watershed/runoff and other resource system relations;
- analyzing masses of data;
- appreciating computer potentials for resolving environmental problems;
- organizing data for management decisions;
- becoming aware of how stochastic elements influence systems;
- assessing risk potentials;
- increasing problem-solving opportunities and abilities;
- helping develop comprehension of concepts;
- encouraging efforts toward optimization (i.e., beyond simulation);
- facilitating remedial learning; and
- stimulating out-of-class continued learning.

Using it as a simulator (e.g., Bell and Linebarger 1970, Hoecker 1976, Lawrence and Konvicka 1976, Waldren 1981, Pieters et al. 1981, Hoover and Markhart 1987), especially with interactive video, the student ". . . can gain experience analogous to that which could be gained from the real situation, without the potential endangerment, confusing complexity, horrendous expense or inaccessibility associated with that real situation "(Taylor 1983:83). Of course, this does not rule out use of laboratory measurement devices for direct data entry to a computer (Olivo 1986) for analysis or as a factor for the simulator.

Computer simulation is a powerful technology, but its power is enhanced when realistic data are available. Availability is enhanced through data bases such as provided by and encouraged by the Multi-State Fish and Wildlife Information System Project. Beyond simulation, in situations in which objectives can be estimated or approximated, then optimization procedures are relevant. Powerful linear and nonlinear solution systems are now available due to computer advances. These objectives, and thus, citizen or client expressions of them, can bring the researcher into the domain of the manager.

Cookingham et al. (1980), supported by others, said that "biological knowledge and competence in managing populations and habitats, through still necessary, are no longer sufficient without complementary skills in environmental, economic, and sociological analyses and the ability to serve a better informed and more critical public. . . ." The same concept was expressed by Teer et al. (1990). They said that there is a need to shift curricula from a research orientation to research/management. This, they said, requires ". . . basic skills in the acquisition and analysis of data, evaluation of actions, synthesis of information, formulation and execution of management action, ability to operate effectively in teams, ability to deal in the area defined by law, regulation, and politics.''

My opinion is that the computer based educational units are so different that they cannot be realistically compared with other educational units. The units and computer environment has great potential for accomplishing well-disciplined, rigorous mastery of learning.

Strengths and advantages of computer use include:

- eliminates excessive often tedious manual computation;
- reduces errors and erroneous conclusions stemming from calculations with such errors;
- is usually non-threatening;
- emphasizes substantive issues rather than computation;
- allows model complexity to be increased;
- allows realism associated with complex, multi-dimensional systems;
- enhances student interest and some motivation (Brown 1986);
- encourages great student involvement and participation;
- allows student and teacher to work together to master computer-contained problems;
- individualizes instruction;
- has branching capability, allowing repetitive work for students who did not master the material on first exposure or moving over material already known or ahead rapidly for gifted learners;
- makes feedback to students fast and real;
- offers rewards and verification of mastery of a concept or topic;
- allows competitive situations to be readily created;
- allows cause-effect investigations to be readily conducted;
- allows problems not tractable mathematically to yield to numerical analyses;
- encourages personal heuristics, especially in problem solving;
- reduces errors and erroneous conclusions stemming from calculations with such errors;
- has clues, helps and other devices—there are no penalties for forgetting;
- has elements of graphics, color, light, sound, animation and a dynamics not readily available in other media;
- encourages repetitive use until mastery is gained;
- reduces needs for texts and ''hard copy'' material; and
- allows more time to be spent afield.

Limitations

The advantages are well-documented. Although evaluation techniques may be faulted, those of us who have used computers in education know of its interest to students, high student motivation, evident interaction and student involvement, and demonstrable score improvements with repetitive use of programs. While improved proofs are needed, wildlife managers are well aware of the difficulties of making such proofs, of separating costs, of properly tagging benefits and of the disparity that exists in value systems between users of a resource, whether of computers or wildlife.

The limitations are many but fall into four categories—''liveware'' or the people to develop the software, educational theory (which will not be discussed here), a supportive environment, a host of general disadvantages and poor programs.

Programmers

Some people have suggested that the programmers or faculty interested in programming or work with programmers are limiting to computer use in wildlife resource management. Increasingly, programs have become available that are easily used and require no computer programming competence. Most learning (Bork 1984) still takes place in conventional, prosaic ways—lectures and textbooks. The reasons he suggested that computers were not used more in university education are: (1) faculty do not know how; (2) they do not have the resources to do so; and (3) the reward system does not encourage it.

Academic Environment

As Drew (1989:60) said, "there is an entire generation of academics who need computers to link them to the great research centers of the country." He found that among the universities receiving small amounts of federal research support, new faculty ". . . found it virtually impossible to develop productive research careers." These institutional environments, the ecosystem of the computer user is *a* major barrier (perhaps *the* major one) to computer use and access to research and development carriers. New networking through computers may change the academic landscape and allow personal development even within the second- and third-tier universities (Drew 1989:60).

General Disadvantages

Use of computers in education is clearly widespread. It has great utility for a variety of tasks and potential for many students in a variety of teaching-learning situations and multiple objectives. Nevertheless, it has disadvantages or limitations, as do all techniques. Sales people are at fault in "overselling" products; teachers are at fault in not tying use to clear objectives and educational theory; students share fault in not using the resource creatively or abundantly; administrators may be more prone to weight highly the costs and disadvantages than the advantages and behavioral change that occurs per dollar spent. The notable disadvantages are:

- often, the need is not seen—there is no "market pull" (Drew 1989:14);
- students and others may not appreciate the time required for programming;
- learning time for use is very great;
- enormous amounts of programming time are required;
- programming may meet an educational objective but one that may change (due to course assignment, student enrollment, etc.) and work may appear wasted;
- the complexity and "content" may be hidden—too many assumptions may be required;
- costs of software development are high;
- there are high risks of computer use—successful completion, acceptability, positive influence on students, faculty reputation, rewards and program stability;
- faculty may lose some independence due to becoming partially dependent on local computer service organizations and facilities (Smallen 1989);
- hardware limitations are great for classes and group presentations;

- some teaching and research are disrupted by computer use (Drew 1989);
- unrealistic assumption or restrictions may be needed to make units educationally suitable;
- hardware difficulties often occur at critical times;
- hardware is dynamic, often requiring changes in programs, concepts, methods of presentation and development and, thus, support staff and costs;
- programs made by assistants are difficult to revise;
- faculty promotion-tenure decisions and related reward systems do no seem to reflect the faculty investment in such computer units;
- grading of unique usage of programs is difficult (Giles 1987);
- there are great variations in student computer skills and aptitude;
- local assistants or advisory resources are not available;
- much computer work requires a type of creativity which may not be important in some areas as mastery of a body of knowledge; and
- there is comfort with the "old way"—what to expect is known; uncertainty (thus, risk) is reduced.

As Drew (1989) said, the technology was excellent even in the 1960s but potential users could not be persuaded that computer-aided instruction would ". . . assist them in reaching their teaching or learning goals." I have a feeling that they could be persuaded, and some were, but that there were constraints of money, hardware, software, administration, the silly requirements for "justification" for a *new* system based on proof of *past* performance, and over-emphasis on failures of fallible humans made conspicuous by the machine.

Programs Per Se

Bork (1984) detailed poorly designed educational software:

- failure to use interactive capabilities;
- failure to individualize instruction;
- use of weak forms of interaction (e.g., multiple-choice questions);
- heavy reliance on text;
- use of pictures only slightly related to objectives of the unit;
- use of monitor screen as if it were a book page;
- units that do not fit into a curriculum;
- use of games that have no educational merit;
- long sets of instructions at the beginning of a unit;
- heavy use of auxiliary print material;
- segments of content placed out of context; and
- materials that do not hold students' attention.

A peculiar shift in logic has occurred among some critics. For years in conferences there have been expressions of need for problem solvers. Now the fear is that computer use only produces "solvers," not those who can formulate the problems.

Available Programs

At one time, there were claims of the field being hardware wealthy and software poor. In the mid-1980s there were calls for support for developing educational software.

Some government and corporate investments have been made and major, amazing developments have been made in hardware capability, ease of use, and practice. Now, more than 200 entries are submitted annually for judging in the EDUCOM/N CRIPTAL Higher Education Software Awards competition. A brief list of highly relevant software is presented here largely to sketch the resources now available. Extensive catalogs are also available (e.g., Stein 1987, Queue, Inc. 1991).

Anatomy of a Fish—Ventura Educational Systems, 3440 Brokenhill St., Newbury Park, CA 91320
Animal Adaptation and Identification—Scott, Foresman and Co., 1900 East Lake Ave., Glenview, ID 60025
Animal Reproduction—J and S Software, 14 Vanderventer Ave., Port Washington, NY 11050
Biology Simulations Package III (Predator-Prey)—Albion, Div. of Queue, Inc., 562 Boston Ave., Bridgeport, CT 06610
Knowledge Master-3—Academic Hallmarks, P. O. Box 998, Durango, CO 81301
Family Identification (Botany)—Conduit, Univ. Iowa, Oakdale Campus, Iowa City, IA 52242
Air Pollution—Educational Materials and Equipment Co., P. O. Box 2805 Danbury, CT 06813–2805
Aquatic Ecology—Oakleaf Systems, P. O. Box 472, Decorah, IA 52101
Simulation (Aquatic systems)—Oakleaf Systems
Ecological Data Simulation—Oakleaf Systems
Ecology—Silwa Enterprises, Inc., 2360–J Geo Washington Hwy., Yorktown, VA 23666
Ecology—Scott, Foresman and Co.
Ecological Modeling—Conduit
Niche—(Ecological/Simulation)—Diversified Education Enterprises, 725 Main St., Lafayette, IN 47901
Balance—(Predator-Prey Simulation)—Diversified Education—Enterprises
Pollute—Compuware, 15 Center Rd., Randolph, NJ 07869
Evolut (Evolution and Natural Selection)—Conduit
Simulated Evolution—Life Science Associate, 1 Fenimore Rd., Bayport, NY 11705
Forest Fire Dispatcher—Duane Bristow, Rt. 3, Box 722, Albany, KY 42602
Forest Sample Database—Duane Bristow
Life—Queue, Inc.
Advanced Genetics—Educational Materials and Equipment Co.
*Grade Keeper-PC*Oakleaf Systems
Baffles—Conduit
Tribbles—Conduit
Life Tables and the Leslie Matrix—Conduit
Rats (IPM Control Simulation)—Compuware

Giles (1987) made available as freeware two diskettes of wildlife-related programs under the topics of animal populations, abiotic factors, time, space and habitat, math and statistics, management, variety, ponds and streams, overview and utilities, and social engineering.

Conclusion

There is little use of the computer in wildlife education but there are notable exceptions. There is abundant use in universities, in general, and wildlife professors and students may, with little effort, gain access to computer resources.

There are likely to be extensive changes in computer use within the university and, thus, in wildlife management education within it. These may include:

- improved rote memory aids (e.g., Wheeler 1987);
- self-operated testing devices;
- increased visualization of data sets prior to statistical analyses (Chapra and Canale 1989, Wulf and Rosenberg 1990);
- Creation of complex educational games dealing with ecosystems and managed units;
- increased use of optimization algorithms (e.g., minimax) in decision-based programs;
- expanded use of hypermedia in yet-undreamed applications (Trynda 1979, Bourne et al. 1989, Beal 1989, Jaffe and Lynch 1989, Jones 1990, Havholm and Stewart 1990, A. Moen 1990, personal communication);
- Revisions of the scholarly journal and the means of reporting research on making technical reports (Louie and Rubeck 1989);
- increased change in the university library itself and transmission of knowledge on campus and to distant users (Greenberger 1984, Kastella and Gordon 1989, Didier 1990);

Because of rapidly changing hardware, accessibility of easily used software, high education costs, significant educational advantages and some peer pressure, the computer will be used increasingly in the future university. The amount of use will increase, but the qualitative differences will exceed the quantitative in ways we can only begin to anticipate.

The amounts of information available, stored and retrieveable will become more conspicuous along with the costs and the awareness that the research conceived to be absolutely *needed* cannot be obtained in the time available or with the funds, labor and skills available. Then it will dawn on everyone that the computer and data banks have produced a revolution in thought in the university. Whether its mature form gets to the field, or when, remain questions as well as hints for a hope for the future.

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Generating Information for Fish and Wildlife Management: Summary from the Private Sector

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Introduction

During the past decade, 1980 through 1990, great advances have been made in computerizing data and information on fish, wildlife and habitat, for improving management decisions. Although the majority of these efforts have been by federal and state agencies, various private organizations have developed extensive data bases to prioritize conservation activities, select sites for habitat preservation and enhancement, or more efficiently manage a natural resource.

Federal, provincial and state agencies are usually associated with the development of data bases for fish and wildlife management. Non-profit conservation organizations have similar informational needs as public agencies and have been developing data bases on their own or with the cooperation of federal, state or provincial agencies. The Nature Conservancy (TNC) has been a leader in developing computerized data bases for preserving biological diversity. TNC has computerized their Natural Heritage program using both non-spatial and spatial data bases. In addition, TNC is using remote sensing and existing cartographic data for community identification, analysis and inventory. Ducks Unlimited (DU) has used satellite data to build a Geographic Information System (GIS) describing the wetlands in the prairie pothole region of the US and Canada.

Informational Needs

Non-profit conservation organizations are developing data bases to aid in their decision-making processes. Funding for the conservation activities of these organizations is limited. In the 1970s, conservation organizations received approximately 1 percent of all charitable giving in the US. Today, conservation organizations are still receiving approximately 1 percent of all charitable giving (Jon Roush personal communication: 1991). With limited funding for conservation activities, the projects selected for funding must be those projects that best achieve the objectives of the organization. In the past, many conservation organizations were reactive in nature. That is, the organization would learn of a specific site for protection or enhancement and "react" to this opportunity. TNC, DU and other conservation organizations have become more proactive through the use of conservation data bases. By developing and using conservation data bases, various site specific projects or programs can be evaluated and only those projects or programs which will best achieve the objectives of the organization will be selected.

Non-profit conservation organizations use conservation data bases to help direct field sampling priorities, to set research objectives, to distinguish sites of high conservation potential, to select sites for preservation or enhancement, to aid in development of conservation plans for specific site or region, to analyze the spatial distribution of communities and species, to inventory and monitor resources, and to evaluate proposed sites and conservation programs.

The Nature of Conservancy

TNC has been the leader among the non-profit conservation organizations in the development of conservation data base management systems for the preservation of biological diversity. An international network of conservation data bases has been created by TNC, with the assistance of federal, state and foreign governments. There are a total of 82 data centers which operate in all 50 US states, several US National Parks and designated Biosphere Reserves, Puerto Rico, Canada, the South Pacific, and 13 countries in Latin America and the Caribbean. TNC is best known for the Natural Heritage Data Base. TNC's Natural Heritage Data Base, or the Biological and Conservation Data (BCD) System, is a microcomputer-based data management package that facilitates the collection, distribution and exchange of information pertinent to the preservation of biological diversity. Major classes of the data in the BCD system include information on species and community types and occurrences, sites, land ownership parcels, managed areas, and sources of information. The BCD system is extremely flexible with regard to data retrieval, report generation and data manipulation. The system utilizes a state-of-the-art database management system (Advanced Revelation). The BCD system will run on any IBM or compatible microcomputer with an 80386 or faster processor and a 70mb hard disk. The system represents TNC's sixth generation of biodiversity data management software and is now the standard tool for managing and exchanging biodiversity inventory data in the Natural Heritage Data Center Network.

TNC is also developing and implementing Rapid Ecological Assessment (REA) techniques to provide the information gathering and management framework to fully support important conservation initiatives. The ability to identify and manage important conservation areas is often limited by the lack of current and comprehensive information. REA is an integrated methodology which relies on the use of remote sensing data in the form of aerial photography, videography, satellite data and images, and cartographic analysis to provide reliable and timely data to direct conservation actions. REA is currently being applied to support and complement existing Natural Heritage/Conservation Data Center methodology. REA addresses the critical need for conservation action where baseline biological and ecological data are inadequate, and strengthens TNC's capacities to work with conservation planning at different spatial scales.

REA can distinguish sites of high conservation potential through a telescoping process which utilizes different type and scales of satellite and aerial images. Cost-effective data acquisition efforts are then focussed to provide the critical information required to support different levels of conservation planning. This integration of airborne and satellite imagery analysis with existing information creates an important complementary top-down link to TNC's existing bottom-up conservation approach.

Remote sensing and cartographic support permits managers to view elements of the landscape in context with the overall environment and to visualize the entire bioreserve in a single image. In addition, useful map data, such as tract boundaries and ownership, can be overlaid with the images using efficient and low-cost GIS technology.

The remotely sensed data provide critical information which aid in site design, inventory and monitoring. The format of the GIS allows for ease of capture, display and update of site information. This information provides a permanent record of site history and status.

TNC has developed the Spatial Data Information Center within the Science Division at its headquarters in Arlington, Virginia. Computer resources include one minicomputer and four microcomputer image processing and GIS workstations. These systems use ARC/INFO, a widely-used vector GIS; ERDAS, a raster GIS and image processing system; and MIPS, a raster/vector GIS and image-processing system. The Center continues to evaluate spatial data analysis platforms and software for their ability to meet conservation needs. The systems are equipped with input/output peripherals and are able to produce quality map products. TNC is developing integrated GIS and BCD systems at each of its five regional offices.

Ducks Unlimited

DU's Habitat Inventory and Evaluation (HI&E) program was established in 1984. The National Wetland Inventory (NWI) program of the US Fish and Wildlife Service has done an excellent job in mapping the wetlands in the US. However, in Canada, no comprehensive wetland inventory program has been initiated and for many high priority waterfowl areas in the US, digital NWI data is unavailable. To aid in selecting wetland sites for preservation and enhancement, to identify areas of critical upland habitat for nesting waterfowl, to identify locations for both intensive and extensive approaches for improving nesting cover, to monitor wetland changes, and to evaluate potential waterfowl conservation programs, digital data bases describing the wetlands and uplands for key waterfowl habitats in Canada and US were needed. DU, working with NASA, reviewed various available technologies and ascertained that DU's informational needs could be met through the use of Landsat Thematic Mapper (TM) data. Although this technology can provide a rapid appraisal of waterfowl habitat, it cannot provide as detailed or accurate wetland information as provided by NWI.

DU initiated their habitat inventory program in the prairie pothole region of Canada. In a typical year, more than 50 percent of all breeding ducks in North America nest in the prairie pothole region. This region contains nearly 10 million glacially formed depressions of various size, depth and distribution. Most of these basins are seasonal or temporary and by midsummer, as few as 500,000 basins may contain water.

More than 70 Landsat TM scenes are required to cover the prairie pothole region. DU has complete coverage for this area and has nearly completed the first inventory of wetlands for this region. DU has extensively modified NASA's image-processing package, ELAS, and uses a non-supervised approach to classify full scenes of TM data. The scenes are classified on a superminicomputer and the classified data is written to optical disk. Using a microcomputer image processing system, spectrally similar classes are grouped to informational classes of open water, deep marsh, shallow marks, wet meadow, mud flat, scrub/shrub wetland, forested wetland and riverine. This is an interactive process allowing the analyst to view and edit the groupings of informational classes until the informational classes shown are in full agreement with visual interpretation of the data.

Various maps or map-like products are generated from the Landsat scenes for use by DU's biologists. Using a digital film recorder, TM Bands 3, 4 and 5 are imaged to blue, red and green, respectively, to generate images at various scales. These images have similar coloration as color infrared photography. Using TM Band 5 data, gray-tone maps are plotted at scales of 1:50,000 for Canadian maps or 1:24,000 for US maps. Maps showing the wetland type derived are produced on translucent paper.

The products most heavily used by DU's biologists are the wetland data bases. The Wetland Basin File (WBF) contains the map sheet name on which the basin is found, a unique basin identification number, the UTM zone and coordinate of the northern most point in the basin, the total size of the basin, the acres of each wetland type in the basin, the length of the perimeter of the basin, and an index that describes the shape of the basin.

The file that has been most useful to DU's biologists has been the Quarter Section Land Use (QSLU) file. In the Canadian portion of the prairie pothole region, there are 1.1 million quarter sections (approximately 160 acres) as defined by the public land survey. For each quarter section , the following information is being recorded: the meridian, tier, range, section and quarter section number; total acres of wetlands occurring in the quarter section; acres of various wetland types; total number of wetland basins in the quarter section; and number of wetland basins less than two acres (0.8 ha) found on the quarter section. This data base is nearly completed for all 1.1 million quarter sections in the Canadian portion of the study area. For those quarter sections containing wetlands most suitable for waterfowl, TM data is being used to determine the upland components of land use/land cover. As the upland information becomes available, it is added to the quarter section file. Various categories of cropland, forage, grasslands and forest are used. This QSLU file has become the primary tool used by DU for selecting sites for waterfowl habitat enhancement techniques.

Using the Mallard Model (developed by the US Fish and Wildlife Service) and the QSLU file, various waterfowl habitat enhancement techniques can be evaluated on any area, and the most suitable enhancement technique can be identified.

In addition to the work in Canada, DU has worked with the U.S. Fish and Wildlife Service, Bureau of Land Management, and California Department of Fish and Game in the US. In the US, DU primarily relies on the digital NWI data in combination with TM data.

DU's computer resources include one superminicomputer and three microcomputer image processing systems. Five microcomputer image processing systems are located in Canada and another in DU's regional office in Sacramento, California. DU plans to have additional microcomputer image processing systems in Monterrey, Mexico; Bismarck, North Dakota; and Jackson, Mississippi. DU uses ELAS, ERDAS, MIPS, ATLAS*GIS and ARC/INFO.

Conclusion

There are approximately 11,000 non-profit conservation organizations in the US (Jon Roush personal communication: 1991). Although few of these organizations are currently using computerized data bases for conservation management, the larger of these organizations have great need for these data bases to aid in prioritizing conservation activities, selecting sites for habitat preservation and enhancement, and efficiently managing a natural resource. In many cases, the use of these types of data bases have been the cooperative efforts of non-profit organizations and various government agencies. These partnerships provide very cost effective means of meeting mutual objectives. Advances in technologies have greatly aided the use of computerized data bases by non-profit conservation organizations. Microcomputers with 80386 or faster processors match the performance of many minicomputers, often exceeding $250,000. Landsat TM and SPOT data provide detailed habitat information for minimal expenditures per acre (TM data costs less than 0.1 cent per acre). GIS software designed for microcomputers is rapidly decreasing in price. Some software can be obtained for less than $1,000.

With an ever increasing need for conservation data bases and with lowering costs for computer equipment, software and data, many non-profit organizations will find establishing and maintaining conservation data bases an effective means for improving the efficiency of their conservation programs.

Computerized Information Systems: Meeting the Needs of Fish and Wildlife Management?

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Introduction

The United States and Canada are inhabited by approximately 2,600 vertebrate species of native fish and wildlife (derived from Banks et al. 1987, Robins et al. 1980). As long as humans have inhabited North America, this resource has provided food, clothing and other essentials to a rapidly expanding human population. Today, the continued well-being of this once-abundant fish and wildlife resource, and even the very existence of many species, is in peril. Proper fish and wildlife management, including both vertebrates and invertebrates, is the key to reversing the increasingly desperate status of fish and wildlife.

Federal and state agencies have made efforts to respond to the growing needs of fish and wildlife. As pressures mounted on the traditional game species, the Federal Aid in Wildlife (1937) and Sport Fish (1950) Restoration Programs were established by the U.S. Congress and, as administered by the U.S. Fish and Wildlife Service and the state fish and wildlife agencies, have been very successful in restoring and maintaining many game wildlife and sport fish. And, the U.S. Fish and Wildlife Service's long-standing commitment to management of migratory game bird species has probably mitigated the severity of the twenty-year decline that most waterfowl species are currently experiencing.

The U.S. Congress also passed the Endangered Species Act to protect the growing list of species that were and are nearing extinction. As the lead agency, the U.S. Fish and Wildlife Service is developing and implementing recovery plans for hundreds of species in North America which are threatened and endangered.

These two management focuses—one on game species, and the second on endangered and threatened fish and wildlife—have enjoyed many successes and must be continued. Yet, there remains essentially missing from the federal fish and wildlife programs, a critical and extremely large third component. This missing component of the federal fish and wildlife management system is management of the so-called "watchable wildlife" (or nongame) species. These species, over 80 percent of vertebrate fish and wildlife species in North America (derived from Banks et al. 1987, Robins et al. 1980), are virtually ignored. The consequence of this long-term neglect is that over 275 vertebrate watchable wildlife species in the United States are now officially classified as threatened or endangered by the federal government (U.S. Fish and Wildlife Service 1990). Throughout the 1980s watchable wildlife species, including invertebrates, were added to the rapidly growing list of threatened and endangered species in North America at the average rate of over one per month (derived from U.S. Fish and Wildlife Service 1980, 1990). It is essential that the U.S. Congress complete the federal fish and wildlife management system by establishing programs for conservation of watchable wildlife—the vast majority of wildlife species.

A federal program for watchable wildlife conservation must include many components, such as management, research and interagency coordination, especially with state agencies. The program should be consistent with traditional management, wherein the federal government retains statutory authority for migratory birds and threatened and endangered species, and the state governments retain statutory authority for most other fish and wildlife species. In our view, an important role of a federal watchable wildlife program would be as lead agency, and administrator of a watchable wildlife program similar to the existing Federal Aid programs.

Another important component of a watchable wildlife program is computerized fish and wildlife management information systems. The current shortfall and tremendous need for readily available information about fish and wildlife, although not limited to watchable wildlife, is revealed when examining the list of candidate species for designation as federally threatened or endangered. Of 629 vertebrate candidate species in the United States, 76 percent (478) are Category 2, which contains "Taxa for which there is some evidence of vulnerability, but for which *there are not enough data* to support listing at this time" (underlining added) (derived from U.S. Fish and Wildlife Service 1989). Similarly, of 1,117 invertebrate candidate species in the United States, 81 percent (910) are also Category 2 (derived from U.S. Fish and Wildlife Service 1989). Computerized information systems can help fill these gaps.

Discussion

Since 1969, Congress has adopted at least 13 major pieces of legislation necessitating federal agencies routinely[1] obtain information related to wildlife and habitat if the mandates of the laws are properly fulfilled. Needed information includes: (1) species distribution, density and population changes; (2) species management goals; and (3) habitat relationships. These data have many applications, including use for environmental impact analyses, highway planning, county zoning, surface mining and 404 permits, research, extension information requests, and development of fish

[1]The Endangered Species Act of 1976, Forest and Rangelands Renewable Resources Planning Act of 1974, Resource Conservation and Recovery Act of 1981, National Forest Management Act of 1976, National Environmental Policy Act of 1976, Fish and Wildlife Coordination Act of 1976, Federal Aid in Wildlife Restoration Act of 1976, Federal Aid in Fish Restoration Act of 1976, Fish and Wildlife Conservation Act of 1980, Federal and Land Policy and Management Act of 1976, Surface Mining Control and Reclamation Act of 1977, Clean Air Act of 1970, and Clean Water Restoration Act of 1972.

and wildlife management plans. In response to legislative mandates and fish and wildlife management needs, many federal and state agencies[2] have developed, with various degrees of success, literally thousands of data bases. Following, is just one example each of an unsuccessful and successful computerized information system for fish and wildlife management.

The Alabama Fish and Wildlife Information System

In October 1983, a decision was made by personnel within the Alabama Department of Conservation and Natural Resources to develop a comprehensive information system on species that occur within Alabama. This effort was designed to supplement efforts by the Alabama Natural Heritage Program to compile information on rare and endangered plants and animals. In August 1984, a Memorandum of Understanding was signed between the Eastern States Office of the Bureau of Land Management and the Office of Surface Mining to help fund the development costs of the system. By January 1985, a contract was in place with the University of Alabama, Birmingham, to develop the information system and electronic information on ten species was acquired to use as test data. By August 1985, information was available on more than 500 species. But, by September 1986, personnel changes had taken place within the Alabama Division of Game and Fish and the future of the information system was in doubt. The information system was transferred from the contractor to Alabama Division of Game and Fish in June 1987, where it was essentially not used. Finally, in May 1988, a decision was made to abandon the information system and adopt the information management system already in use by the Alabama Natural Heritage program.

The reasons for the failure of this effort despite considerable funding and effort are speculative, but a lack of agency commitment (that should have been identified early in the planning process) was the ultimate problem. Funding and expertise were available. Personnel to implement the information system after it was transferred to Alabama Game and Fish were unavailable, but this situation should not have been unforeseeable. Fish and wildlife databases require multi-year commitments that could not be achieved in this case.

The greatest impact of the failure of this computerized information system was ultimately on the fish and wildlife resource it was intended to aid. Years of work and many thousands of dollars that could have been more effectively devoted to fish and wildlife conservation were ultimately abandoned. Furthermore, the potential for that data base to facilitate fish and wildlife conservation in Alabama was totally lost.

The Breeding Bird Survey

In 1965, the U.S. Fish and Wildlife Service (Service) initiated the Breeding Bird Survey (Robbins et al. 1986). This computerized information system contains data collected from approximately 2,800 randomly selected roadside counts of birds. Conducted largely by volunteers, this annual survey now provides statistically reliable, long-term trend data for hundreds of migratory birds. Accessible to all potential users, the data are invaluable for assessing trends in breeding bird populations and

[2]For example, the U.S. Forest Service, U.S. Fish and Wildlife Service, Bureau of Land Management, Office of Surface Mining, Soil Conservation Service, Environmental Protection Agency, and Federal Energy Regulatory Commission.

have been used to identify avian species needing special management attention (U.S. Fish and Wildlife Service 1987).

There are many contributing reasons to the success of the Breeding Bird Survey (BBS). One of the most important is the Service's internal commitment to the BBS, although current funding and personnel levels inhibit utilization to its full potential. Other reasons for the BBS's success are that it provides data that are needed for management, and that the system is constantly updated with the most current information available.

The inadequacy of fish and wildlife information systems inhibits proper management and increases the likelihood that effective and efficient management will be replaced by crisis management, which is often ineffective and controversial. For example, the snail darter (*Percina tanasi*) had not been identified or documented before beginning phases of the construction of the Tellico Dam in Tennessee. Had an inventory been conducted and a data base been available and accessible with information about this species, it might have thwarted the waste of sizable federal expenditures and eliminated considerable political controversy.

Lack of critical management information continues to cripple the ability of the federal and state fish and wildlife agencies to effectively manage many of the nation's fish and wildlife species. Although data are routinely collected on most game species and many threatened and endangered species, the vast majority of vertebrate fish and wildlife species—approximately 2,140 (81 percent of the total)—continue to receive inadequate attention.

Conclusions and Recommendations

Efficient and cost-effective fish and wildlife management information systems must be implemented and used to facilitate conservation of fish and wildlife before they require costly and controversial protection afforded by the Endangered Species Act. To meet this need, we make several recommendations.

First, we recommend full funding of the Fish and Wildlife Conservation Act of 1980. This could and should establish, for the first time, a significant source of funding that is not derived from activities associated with hunting and fishing activities. (Over 70 percent of state agency funds are derived from hunters, trappers and anglers by license fees, excise taxes and conservation stamps [derived from The Wildlife Conservation Fund of America 1987].) Therefore, these new funds could be directed primarily to watchable wildlife, including vertebrates and invertebrates. Watchable wildlife species are the most likely species, if not managed now, to need special protection from the Endangered Species Act in the near future.

Second, we recommend the first priority with funds from the Act be assessment (inventory) of the status of watchable wildlife species. This is a pre-requisite to development of comprehensive conservation plans specified by the Act. Only after the status of fish and wildlife has been assessed, can management plans which truly address fish and wildlife management needs be developed.

Third, under the auspices of the Fish and Wildlife Conservation Act and because of the abundance of successful and unsuccessful data systems within the U.S. Fish and Wildlife Service, other federal agencies and state fish and wildlife agencies, we recommend the Service use its existing authority to establish a leadership role in coordinating fish and wildlife information systems. The Service should establish a program to coordinate and provide technical assistance in fish and wildlife database development and management to federal and state agencies. Furthermore, the U.S. Congress should authorize and appropriate adequate funds to the Service to administer this program.

Finally, the state and federal fish and wildlife agencies must make an internal commitment to effectively utilize computerized fish and wildlife information systems to their full potential. Such use will not only increase their cost-effectiveness, but enhance fish and wildlife management.

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Use of Geographically Extensive Databases in Regional Planning Models for Wildlife Resources

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Introduction

Because surveys take up a great deal of time and labour . . . [t]hey have to show a convincing reason for their existence, and not just accumulate a vague mass of field records.
(Elton and Miller 1954:474)

During the 1970s, a series of legislated acts requiring environmental assessments encouraged wildlife resource managing agencies to develop and enhance resource information systems to support objective and timely evaluations of status and trends (Hirsch et al. 1979). Although the motivation for developing automated information systems stemmed proximately from federal and state legislation, the ultimate stimulus was public expectation that natural resource stewards be comprehensive in their management (Dearden 1978). To meet these expectations, resource planners needed to broaden their traditional site-specific focus to include examination of "big picture" trends (Sanderson et al. 1979:167).

Initially, the development of macro-scale wildlife planning models was limited by the paucity of data to analyze regional and national resource policy questions. This availability constraint no longer exists. Federal, state, and private resource agencies have accumulated extensive databases on wildlife resources. However, a critical question remains—are these data useful in explaining and anticipating changes in wildlife resources in response to land use and land management activities?

In addressing this question, we report on two case studies of regional wildlife planning models that were developed in response to legislation requiring the USDA Forest Service (Forest and Rangeland Renewable Resources Planning Act of 1974) and the Soil Conservation Service (Soil and Water Resources Conservation Act of 1977) to conduct national assessments of wildlife resources. The models provide habitat-based analyses of regional shifts in species distribution and abundance patterns and demonstrate the potential utility of extant, geographically extensive databases in regional wildlife planning.

Case Studies

Effective large-scale assessments of wildlife resources will require a mix of single-species and multiple-species approaches (Westman 1990, Yahner 1990). Each of two case studies presented illustrates the application of one of the approaches in regional studies of land use impacts on wildlife resources.

Species Response to Regional Land Use and Timber Management in the South

> *. . . the complexity of nature is not in itself a reason for studying it only small bits, as is the usual practice . . . .*
>
> (Elton and Miller 1954: 473)

The 12-state region bounded by Texas and Oklahoma in the west and Florida to Virginia in the east contains approximately 40 percent of the nation's timberland. Because of its national importance in timber production, considerable concern was generated when recent declines in net annual timber growth were noted (USDA Forest Service 1988). This observation prompted the organization of a regional study of the South's timber supply situation. Unlike previous timber policy studies, however, a broader resource planning perspective was taken—one that acknowledged the joint production of timber, forage, wildlife, fish and water from forest lands. This represented an opportunity to test the utility of geographically extensive wildlife databases in a decision-making forum that had regional policy and program implications.

Data sources and habitat models. Regionwide habitat models relating land use and land cover characteristics to distribution and abundance patterns of selected wildlife species were derived empirically (Flather et al. 1989, Flather and King in press). The county served as the observational unit for habitat model development. Acreage in broad land-use categories (forest, crop, pasture/range, urban), forest type and forest age within counties were obtained from the National Resources Inventory (USDA Forest Service 1985). Regional distribution and abundance data existed for white-tailed deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), and red-cockaded woodpecker (*Picoides borealis*). Deer and turkey data were obtained from the Southeastern Cooperative Disease Study, University of Georgia. Data on the distribution and number of active woodpecker nesting colonies within a county were obtained from the literature, state wildlife agencies, Forest Service biologists, and state natural heritage programs.

Discriminant function analysis (Johnson and Wichern 1984) was used to develop statistical relationships between county-level land use and forest characteristics, and density classes (low, moderate or high) for deer and turkey, and presence/absence of active woodpecker nesting colonies. Habitat relationships identified through discriminant analysis were consistent with literature and expert accounts of life history requirements.

Model application and performance. Basic assumptions concerning population growth, economic growth, and timber management were used to project decadal shifts in land use and forest inventories from 1985–2030 (Joyce et al. 1990). Changes to the land base were translated into wildlife response through the discriminant models. Under an assumed future characterized by land management intensification, urban land was projected to increase; natural pine was converted to pine plantations; and both younger and older age classes of hardwoods increased (Figure 1A). Wildlife response (Figure 1B) was not unexpected, with both deer and turkey projections showing initial declines in average density. The number of counties expected to support active nesting colonies of red-cockaded woodpecker showed the greatest declines as older natural pine was harvested and brought into short-rotation management.

While this application demonstrated that extant habitat and population databases could be used to explore wildlife response to land management, the question of whether the models provided useful information (i.e., valid habitat relationships) required further examination. Model performance was evaluated by use of cross-validation procedures (Efron and Gong 1983) to approximate model accuracy expected under tests using independent data. Classification accuracy of the models was 60 percent, 67 percent, and 76 percent for deer, turkey, and red-cockaded woodpecker, respectively (Flather and King in press). Despite moderate classification accuracy, performance of all models was shown to be better than that attainable by chance ($P < 0.001$, kappa statistic) (Cohen 1968, Titus et al. 1984).

Evaluating Wildlife Community Response to Land-use Intensification

Given the enormous variety of species; . . . it simply is not possible to construct models for all species and circumstances.

(Emlen and Pikitch 1989:253)

In the early 1980s, the Soil Conservation Service initiated a study to explore the feasibility of applying a wildlife diversity methodology (Streeter et al. 1983) to meet

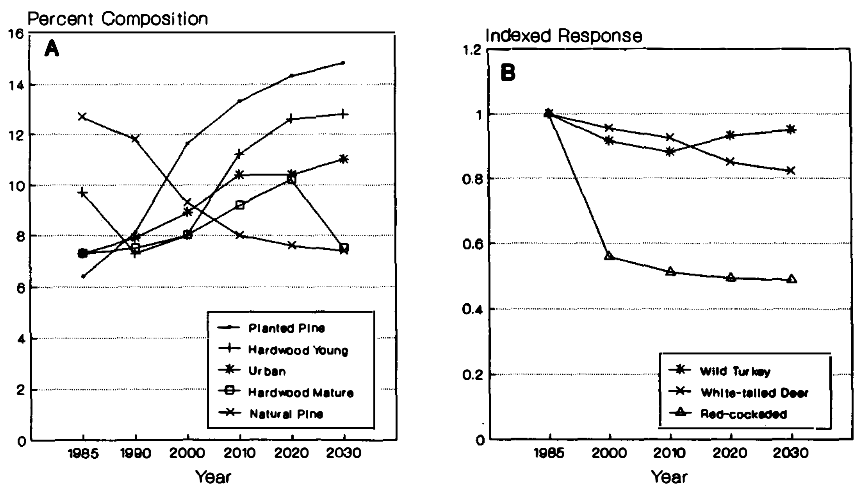

Figure 1. (A) Projected (1985–2030) changes in land use and forest characteristics, and (B) modeled response of selected wildlife species over the southern United States.

their national planning mandate specified in the Resources Conservation Act. The approach was based on a fundamental ecological observation: habitats that are more structurally complex tend to support a greater diversity of species (MacArthur et al. 1962).

The habitat structure index of wildlife community status. Wildlife habitat can be conceptualized as being structured as a series of layers that provide both nesting and foraging life requisites. This conceptualization has been used most often as a framework for delineating species guilds (Short and Burnham 1982, Szaro 1987). The concept, however, can also be used to rank habitats according to vertical habitat complexity (Asherin et al. 1979, Short 1982, 1988). Streeter et al. (1983) developed a model that calculates a relative index of vertical habitat structure by comparing inventory-based counts of available habitat layers to the number of layers expected under natural vegetation. The index tends to vary between 0 and 1 and indicates the extent to which current land use has simplified vertical habitat structure.

We used the habitat structure model to depict recent geographic pattern in vertical structure using the 1982 National Resources Inventory (NRI) (USDA Soil Conservation Service 1987). Because the NRI only inventories non-federal lands, we limited our examination of the model to the eastern United States to minimize the influence of federal land on our evaluation of habitat structure (Flather et al. in prep.). The spatial pattern of vertical habitat structure was consistent with conventional wisdom: intensive agricultural regions of the midwest and Mississippi Valley showed low index values, while New England, the Southern Appalachians and northern portions of the Great Lakes region have retained a greater proportion of the vertical habitat structure expected under natural vegetation (Figure 2). Although the model was consistent with our expectations, explicit tests involving measures of wildlife community structure would provide a more powerful evaluation of the model.

Testing model predictions: faunal integrity and community dominance. Two measures of avian community structure derived from the U.S. Fish and Wildlife Service Breeding Bird Survey (BBS) (Robbins et al. 1986) were used to test the habitat structure model. First, a measure of avian community integrity was calculated as the proportion of the expected avian community that was observed by the BBS. Expected avian community composition was determined from a continent-wide range map study conducted by Inkley (1985). A second measure of avian community structure examined the dominance pattern of species. The Berger-Parker index (Magurran 1988) expresses the proportional contribution of the most abundant species to the total number of individuals inhabiting a region. These measures of avian community structure were an attempt to capture two aspects of community simplification that could occur under land use intensification—the loss of species richness and shifts in the distribution of species abundances toward communities dominated by a few generalist species.

The vertical habitat structure index and avian community measures were calculated for landscape-scale geographic units defined by Major Land Resource Areas (MLRA) (USDA Soil Conservation Service 1981). These MLRA-defined landscapes formed the observational unit for statistical tests of the relation between vertical habitat structure and avian community metrics.

Spearman rank correlations and simple linear regressions provide support for the

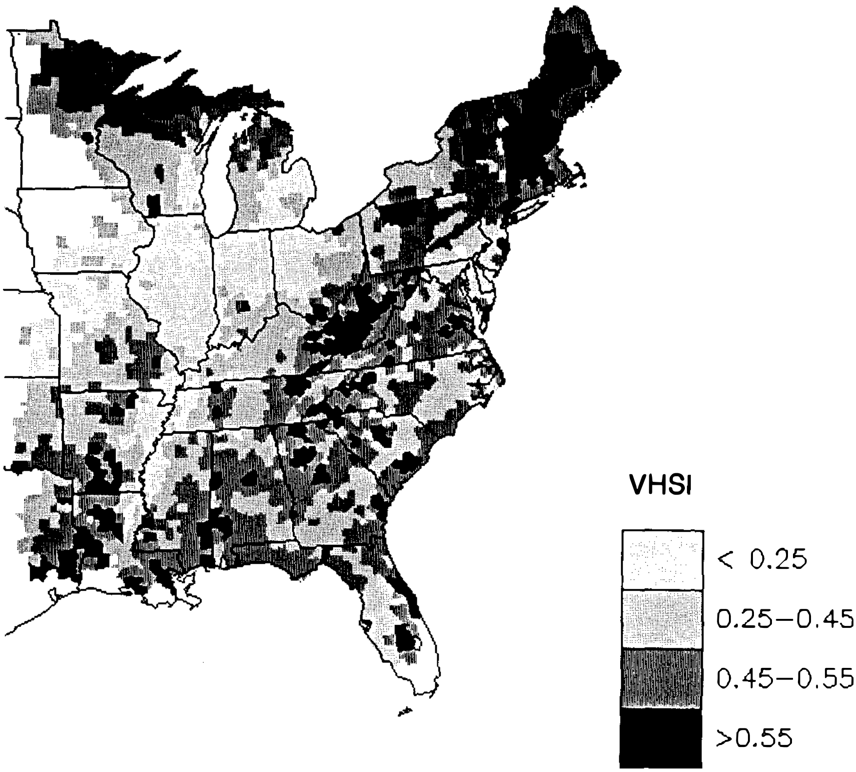

Figure 2. County-level mean vertical habitat structure index (VHSI) for the eastern United States.

fundamental assumption underlying the habitat structure model, indicating that landscapes under intensive land use have also witnessed simplification in avian community structure. Avian community integrity and dominance showed statistically significant but weak relations with vertical habitat structure (Figure 3). These results indicated that substantial variability in avian community structure remained unaccounted for by the habitat structure model. A factor lacking in the habitat structure model is a horizontal component of habitat structure (i.e., the size, shape, and spatial distribution of land types). Consequently, it was not surprising that a model characterizing only vertical habitat complexity accounted for only a portion of the total observed variation in the avian community measures chosen here.

Implications for Information Systems and Resource Planning

In the above case studies, we have reviewed past attempts by two natural resource agencies to assess wildlife resources as a function of current and anticipated land use and land cover patterns over broad geographic regions. These case studies have attempted to go beyond feasibility tests to actual quantification of model reliability. In addition to providing baseline performance estimates of regional wildlife models,

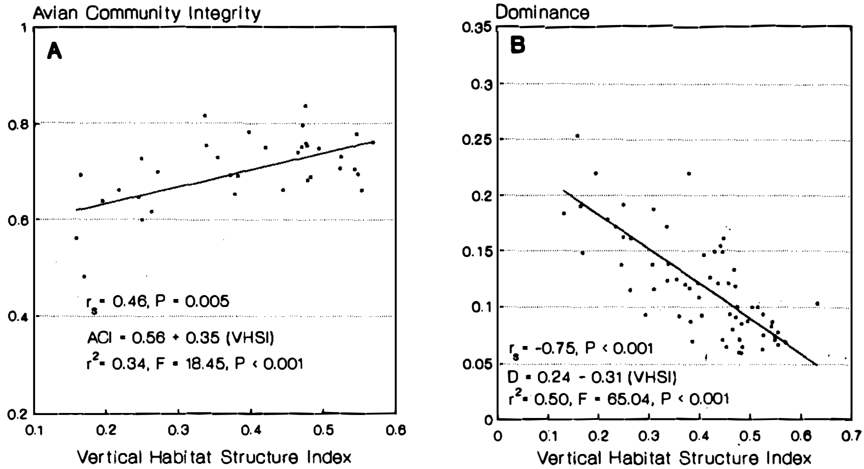

Figure 3. Spearman rank correlation (r_s) and linear relation between vertical habitat structure index (VHSI) and (A) avian community integrity (ACI) (n = 35), and (B) Berger-Parker index of community dominance (D) (n = 66).

the analysis and results reviewed here also are of heuristic value in suggesting further research.

The differential model accuracy, noted in the single-species response models, raises an important question regarding the influence of species life history and scale in evaluating habitat models. Kolasa (1989) and Hunter (1987) have conceptualized habitat as being perceived at a hierarchy of scales. The implication is that the scales of habitat inventories and policy questions may dictate which species are appropriate candidates for habitat model development. The magnitude of the unexplained variability in avian community measures indicates a need to explore the incorporation of spatial configuration measures in models attempting to explain wildlife community response within managed landscapes (Flather et al. in prep.).

The point we wish to stress is that information system design must be coupled directly with analyses that demonstrate database utility. Ideally, information systems should attempt to define basic data elements that are robust to a wide variety of analyses under an adaptive design. The information content of a database is increased when it can be related to other independent data sets to analyze complex multiple resource issues or validate relationships. Failure to link information system design and analysis in a process that continually evaluates database performance could result in weak planning decisions and limited capability to explore improvements in models and resource inventories that are an important base for resource planning.

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The Use of Computerized Databases in Management and Planning of Protected Areas in Venezuela: A Case Study in the Santos Luzardo National Park of Southern Apure State

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The national park system in Venezuela, begun in 1937 with the creation of the Henri Pittier Park, has grown rapidly to include 35 natural areas. The amount of land included in the system now comprises one of the largest percentages of the national territory of any country in Latin America. Parks were declared to protect areas of natural scenic beauty, large concentrations of wildlife or unusual geographic features, but little scientific information was available to guide legislators with these choices.

Here we describe the process used to create the Santos Luzardo (Capanaparo-Cinaruco) National Park in southern Apure State, which came to be as a result of a multidisciplinary team's efforts to create a computerized database for regional development planning in the western llanos of Venezuela. Very few, if any, computerized databases have been used in the process of national park creation any place in the world.

In 1984, the National Fund for Agricultural Loans (FONAIAP), the governmental agency responsible for agricultural investment in Venezuela, contracted UNELLEZ to draft a regional development plan, that was to include evaluation of the natural resources, and would integrate future needs for urban and agricultural development with conservation principles.

UNELLEZ is a relatively new university system created in 1973. Our department, Environmental Engineering and Natural Renewable Resource Management, has operated in Guanare since 1978, along with Agronomy and Animal Husbandry departments. In addition to the usual educational facilities one would expect, UNELLEZ has grown to include a Zoological Museum (MCNG), an Herbarium (PORT) and a Cartography Center. We also have a Masters Degree program in Wildlife and Fisheries Management, supported by the U.S. Fish and Wildlife Service. An extension program (COFIP) provides planification services and faunal surveys for private landowners interested in wildlife production.

Drawing on this concentration of resources, a multidisciplinary team, known as APUROQUIA, coordinated by regional planner Prof. Luis Barreto, was formed to meet the challenge presented by FONAIAP. The team was divided into functional groups, each to tackle a different aspect of the problem: agricultural production, soils, demography and workforce characteristics, urbanism, industry, economy, tourism, technological levels, forestry, transportation and road systems, hydroclimatology, wildlife and fisheries.

The primary objective of each group was to gather available information about their topic, and to reduce these data to a common denominator that would allow the consideration of each in the decision-making process. After information was collected, "holes" in the database were identified, and efforts to generate appropriate information were undertaken. Current regional development patterns and projected future land uses were evaluated.

APUROQUIA was defined to include the states of Barinas, Portuguesa, Cojedes and Apure, and is comprised of mountain regions, most of the Andean piedmont and all of the western plains, known as "llanos" in Venezuela. The vast flatlands comprise most of the area included, and cover approximately 125,700 square kilometers in Venezuela (they extend well into neighboring Colombia). The Andes mountains form the northern and western borders of the llanos. Agriculture and cattle ranching are the principal productive economic activity in this area. Some 3 million hectares, comprising 43 percent of all agricultural lands in the country, are cultivated. Of the total area of the llanos, some 48 percent is classified as "without use but associated with agriculture." Forestry plantation potential is high but only 3 percent of this area is actually dedicated to sustainable forest production. Industrial development in the region is recent and limited. Fisheries are primitive, but fish stocks of larger predatory species already show signs of overexploitation.

To be able to include all of this diverse information in the development of a regional development plan, an information management system was developed. The system was based on thematic mapping procedures, and carried out on a small microcomputer, the Epson QX–10, with 256K of RAM, and a 10-megabyte hard disk, running at 4 MHz. This information system was programmed to convert all information to a scale of 1:250,000, and used a grid system of 1 by 1 centimeter, the equivalent of 2,500 meters on each side, or squares of 625 hectares. A searching system was developed that allowed the grid system to be referenced by the standard geodesic system.

Basic thematic information was included for: vegetation formation, altitude, percent of deciduous species, height of the trees, density of trees, physiographic landscape, and human intervention of the vegetation; soils, granolometry, orders, potential use, slope; climate, annual mean precipitation, precipitation isotherms, excess water, water deficit, coefficient of variability, superficial water, periodic and occasional events, events of zonal and amplitude fluctuation, generalized climate events of long duration, periodic generalized climate events; current land uses were subdivided into commercial horticulture, commercial fruit culture, plantations, annual mechanized plantings, subsistence farms, intense cattle ranching, semi-intensive cattle production, extensive cattle ranching, and no agricultural use. Each of these variables was weighted in light of its relative importance for each cell. Thus, each of the 23,000 information cells contained a datum for each variable. To make sense of this sometimes bewildering amount of information, searches for different sets of correlated conditions were made. In this way, the region was eventually zoned into areas suitable for the different sorts of uses defined in the original objectives (i.e., agricultural development) as well as other criteria.

With this tool, and taking into account the field experience of the members of the fauna and fisheries teams, maps were created to delineate areas important for fisheries and wildlife management. Areas were identified that had high "ecological" scores (i.e., with relatively little intervention) for the protection of biodiversity. We plotted known or probable distributions for endangered or threatened species, as well as those areas of important populations of commercially valuable wildlife or fisheries species, and also included areas with species that posed some threat to health (such as vampire bats or other rabies vectors). Combining fauna and fisheries data with those from the vegetation and ecology teams permitted the creation of systhesis maps that showed areas of high ecological diversity, and the presence of endangered species.

During the project, we were contacted by BIOMA, a private foundation dedicated to the conservation of biological diversity in Venezuela. They had been working with INPARQUES, the division of the Venezuelan Environmental Ministry (MARNR) that is responsible for the selection and operation of national parks and monuments, and were looking for ways to define areas worthy of inclusion in the national park system. We had the information they required, and used the database to plot areas of highest biodiversity associated with little intervention. One of the areas indicated was the region of the Capanaparo and Cinaruco river basins in southernmost Apure state. After additional studies by MARNR, INPARQUES and BIOMA, the "Santos Luzardo" park was created on February 1988. This park, located between the Capanaparo and Cinaruco rivers, comprises 584,368 hectares of lowland savannahs dominated by *Trachypogon and Paspalum* grasses. Wildlife is concentrated in gallery forests along the main rivers and many "morichales" (small creeks of tea-colored water where the moriche palm is the dominant tree). Many endangered or threatened species such as the giant river otter (*Pteronura brasiliensis*), the jaguar (*Panthera onca*), two large sidenecked turtles (*Podocnemis expansa* and *P. unifilis*), the Orinoco crocodile (*Crocodylus intermedius*), the manatee (*Trichechus manatus*) and the tapir (*Tapirus terrestris*) inhabit the park. The main attraction to the park is sportfishing for peacock bass (*Cichla* spp.).

Remote Sensing for Nongame Wildlife Habitat Management

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Nongame Wildlife as Biodiversity Indicators

Natural resource professionals have been hearing a lot lately about two ''new'' ideas: *biodiversity* and *conservation biology*. Despite recent publicity about endangered species and the extinction crisis, an understanding of biodiversity and conservation principles has long been a cornerstone of wildlife biology. Wildlife management has always addressed population, community and ecosystem processes that regulate wildlife species, and it was the dean of wildlife biologists, Aldo Leopold, who first spoke of the ''land ethic.'' An increased public interest in wildlife, including a focus on those species that are neither hunted nor fished, has led many state wildlife agencies to broaden the range of species they actively monitor and manage, placing them on the front lines of the biodiversity issue.

Biodiversity includes ecosystem or community diversity, species diversity, genetic diversity and the diversity of ecological processes. The vast majority of species are invertebrates, followed by plants. Only 3 percent of all described species are vertebrates, and only a few of those are game species (Wilson 1988). The challenge of addressing biodiversity through wildlife management seems daunting until one recalls the ways biodiversity is organized and distributed. Species fill ecological niches in broader communities that include primary producers (plants), consumers (insects, other vertebrates) and decomposers (bacteria, fungi, invertebrates). To a large extent, wildlife species are useful indicators of the distribution and condition of overall biodiversity.

The majority of wildlife species are generally classified as ''nongame'' wildlife. In Oregon, for example, about 85 percent of its 772 vertebrates are nongame species. It's neither practical nor necessary to monitor the population status of these species over every square mile of their range. The distribution of their typical habitats is frequently a useful indicator of their distribution. Intensive field survey efforts should concentrate instead on special interest species.

Habitat Relations Models

"Habitat is the place where an animal finds the required arrangement of food, cover, and water to meet its biological needs" (Maser and Thomas 1983:5). Species with similar habitat requirements occur together in communities, whose composition is more or less constant and predictable. Although a variety of environmental factors (soil, microhabitat features, moisture, etc.) contribute to habitat suitability, the plant community type is a useful and visible integrator of habitat components in an area (Maser et al. 1984).

Vegetation has long been recognized as an important factor regulating animal distribution. Grinnell (1917) noted that "because of the close dependence of most mammals and birds upon plants, the latter have an important place in any treatment of animal distribution." Later, Baker (1956) stated that "Mammals generally are confined to specific kinds of plant associations from which they derive either food or shelter or both. Once the investigator has learned the ecological preferences of a given kind of mammal, he can map the occurrence of that mammal by noting the occurrence of the plant." Armstrong (1972) declared, "It is a fact that an experienced observer can look at a given local site and predict with considerable accuracy the kinds of organisms that will be found there."

During the last decade there has been considerable effort to refine and quantify the relationship between animal species and their habitats (Thomas 1979, Verner et al. 1986). The simplest models predict the presence or absence of a species in a habitat, while more complex models address the abundance of a species under different management regimes.

Habitat models are useful tools for predicting species composition and response to management activities. As with my prediction, the chance of making an accurate prediction declines as the prediction becomes more specific in time and space. If we predict that squirrels live in forests and kangaroo rats inhabit deserts, our changes of being correct are very high. When we predict that a western hemlock-Douglas fir/western red cedar forest 80 years old will support a population of two chickadees per hectare, the chances of any real forest stand exactly matching the prediction are correspondingly lower.

The mixture of dominant plants in a vegetation type varies more or less continuously, but we classify vegetation into a discrete number of units. Classifications of the same area can differ considerably. Miller (1951) recognized 22 "ecological formations" in California, while Mayer and Laudenslayer (1988) described 54 "wildlife habitats" in the state. Holland (1986) divided California into nearly 400 "natural communities." Animal species tend to respond to vegetation structure more than floristic composition, so wildlife biologists often combine similar vegetation associations into a smaller number of wildlife habitat types (Maser et al. 1984).

The response of animals to different habitat variables has been studied in few species. The specific habitat requirements of most game species and many endangered species are known in some detail, but there is little quantitative information about the response of most animal species to habitat variation. Some species, like frogs and toads, are microhabitat specialists and can be found in a variety of vegetation types so long as the appropriate microhabitat (in this case, ponds or streams) occurs. Most small mammals and breeding birds display habitat preferences that reflect their morphological and behavioral adaptations. Wide-ranging large animals, especially carnivores, may use a number of different habitat types in their wanderings. These factors place limits on the predictive ability of wildlife/habitat models. Wildlife/habitat models are most useful dealing with simple questions about more general wildlife habitat types. However, given the impracticality of field surveys of large areas, models are a guide to wildlife distribution and, in some cases, abundance. They do require field validation, especially when management action is contemplated for a particular site on the basis of model predictions. Models don't provide new information, but they can organize our collective knowledge and provide first approximations of the wildlife community of a given area.

Remote Sensing of Wildlife Habitats at State and Regional Scales

State wildlife agencies are faced with an information dilemma. Accurate field data are available from a few selected sites, but the agency has the responsibility to manage for wildlife over millions of acres. Cost alone precludes intensive field inventory and monitoring. The development of satellite imagery provides a partial solution to this problem. Statewide mapping of vegetation cover types is now practical. While micro-habitat features cannot be mapped, their presence can be inferred as expected landscape components. The manager is provided with information about the area, distribution, dispersion and, to some degree, the condition of stands of vegetation. Most human disturbances are easily visible in most satellite imagery, and habitat loss to residential or agricultural uses can be quantified. Many management practices, such as timber harvest, also leave characteristic patterns on the land, and the location and extent of forest fragmentation can be determined.

There are several satellite products available for remote sensing of wildlife habitat (*see* Tueller 1989). In Oregon, we have used false-color infrared positive prints of LANDSAT MSS scenes at a scale of 1:250,000 to determine boundaries of vegetation stands. In many cases vegetation cover could be determined from the satellite images. In other areas information from on-the-ground surveys was used to label or confirm labeling of cover types. In both California and Utah, LANDSAT TM (Thematic Mapping) imagery is being used because of its finer resolution (30-m pixels as opposed to 80-m pixels for MSS). Other advantages of TM over MSS are: (1) the additional information in the mid-infrared region corresponding to soil moisture and leaf water content; and (2) finer radiometric resolution, i.e., better discrimination of canopy reflectance. We are also comparing the cost and efficiency of using digital imagery as opposed to positive prints for determining cover type boundaries (represented as polygon boundaries in a Geographic Information System). Since many applications of a digital vegetation map require high resolution, thematic mapper digital products expand the user audience for the vegetation map. However, MSS imagery is satisfactory to depict habitat stands at the scale used by populations of most wildlife species. The historic 2.5 million hectare range of the endangered California condor was also mapped by photointerpretation of 1:250,000 scale prints of Landsat TM data (Stoms et al. in review). Alternatively, computer-assisted classification of digital imagery has been applied to map habitat over large regions of Alaska (Talbot and Markon 1986) and grizzly bear range in the North Cascades of Washington (Agee et al. 1989). Imagery from several dates and ancillary data such as elevation are often used to help discriminate spectrally similar but ecologically distinct classes (e.g., Talbot and Markon 1986).

Despite the common use of remote sensing to map habitats, these data have been surprisingly underutilized in the actual development and testing of wildlife habitat relationships models (Mayer 1986). By integrating habitat inventories with species observation data in a GIS database, researchers can infer habitat preferences of nongame species (e.g., Stoms et al. in review). GIS-derived habitat associations can then be applied to the habitat inventory to identify potential sites to sample for rare species populations in new locations or to consider for reintroduction of captively-reared ones (Saxon 1983). GIS techniques have also been developed to incorporate information on the spatial configuration of habitats, such as edge effects, in predicting landscape level suitability (Mead et al. 1981).

We would not want to convey the impression that remote sensing is a panacea for wildlife managers nor that regional vegetation maps derived from satellite imagery will serve all potential users equally. The inevitable cartographic generalization in a state, regional or national vegetation map precludes consideration of micro-habitat variation within stands of wildlife habitat for particular species. Features such as snags, downed logs or rock outcrops play an important role in determining the suitability or quality of stands of wildlife habitat for particular species. The presence of such features at a particular site must be determined through field investigation. Obviously, some degrading influences on habitat quality such as pesticides in the food chain or poaching will not be detected by sensors. Small-scale vegetation maps also suffer from classification errors, particularly when evaluated at precise locations. The habitat map for the California condor project was estimated to be about 76 percent accurate across a sample of large field sites, even though the habitat classification system was fairly simple (Stoms et al. in review). For broad-scale applications or as part of a multiscale study, however, remote sensing provides the most practical source of data for predicting nongame species distributions.

Conserving Biodiversity by Managing Nongame Wildlife

Perhaps one of the most useful applications of a GIS data base on the distribution of vegetation types and vertebrate species is the management of nongame animals. Only a small fraction of wild animals are hunted, trapped or fished. Yet, because the funding of state and, to some extent, federal wildlife programs has in large part depended on license sale revenues and taxes on hunting supplies, game species are typically the main focus of research and management activities. In the last few decades, another small group of species-—rare, threatened or endangered ones—has commanded a growing portion of public attention and wildlife agency funding. This leaves the vast majority of species, unhunted species not threatened at the moment, without effective management.

If there's one thing we can predict with certainty, it's continued growth of the nation's and world's human population and, with it, continued loss of natural communities. Areas seemingly remote or inhospitable today will succumb to tomorrow's plow or bulldozer if we project our planning horizon beyond a few decades. This habitat loss can also be predicted to drive many seemingly secure wildlife species toward endangerment, with all the attendant costs and controversy. These problems could be avoided if only wildlife management agencies had a cheap but reliable system to anticipate the consequences of future changes in land use and exercised their regulatory and acquisition options to maintain viable samples of habitats that support today's nongame species.

Since the resources of most wildlife agencies are already stretched thin, it is impractical to expect inventory, research and monitoring funds to be directed toward myriad nongame species. However, there is a practical indirect way to monitor their status using habitat (vegetation) as an indicator of their distribution and, to some extent, population sizes.

The same principle of wildlife habitat relationships that allows us to create maps predicting the distribution of these species enables us to monitor their status (current area occupied, dispersion of populations, isolation of populations) and anticipate future trends. If, for example, this approach had been applied to the inland valleys of southern California, the consequences of loss of habitat to orchards and subdivisions would have been predicted well-before the long-eared kit fox (*Vulpes macrotis macrotis*) was driven to extinction and Stephen's kangaroo rat (*Dipodomys stephensi*) became endangered. Only now are local agencies looking at remaining a habitat in an attempt to plan future patterns of development so as to avoid driving the California gnatcatcher (*Polioptila californica*)—an obligate resident of coastal sage scrub vegetation—to endangerment.

It is a widely held misconception that species that are apparently secure today will remain so into the indefinite future. Two centuries ago, many extinct or endangered species (black-footed ferret, *Mustella nigripes*; passenger pigeon, *Ectopistes migratorius;* ivory-billed woodpecker, *Campeohilus principlais*; California condor, *Gynnogyps californianus*) were likewise considered "secure." There are many habitat types that are experiencing slow but steady erosion. There is no regeneration in most stands of valley or blue oak woodland in California at a time when older oaks are dying or being cut for firewood. Several million acres of sagebrush scrub (with bushes decades to centuries old) in the Great Basin are being chained or burned so that exotic grasses can be seeded for cattle forage. Nearly all of the lowland forests of the Pacific Northwest, stands that were hundreds of years old when Lewis and Clark first saw them in 1805, have or will be converted from multi-layered old growth stands to managed forests with little understory and no structural or floristic diversity. We haven't fully studied the community composition or function in ancient forests—forests in which we know that over 250 species of predatory beetles play a role in regulating the invertebrate community that resides within downed logs—but we have elected to destroy most of this segment of global biodiversity.

There are no more frontiers on this planet, yet we destroy ecosystems as if natural communities were limitless and could be regenerated within a fraction of a human lifetime. In reality, no species, with the possible exception of those that have adapted to human-altered habitats, can be considered secure. Those not adequately represented on existing managed areas are almost certainly threatened if land use changes are projected far enough into the future.

Perhaps the greatest challenge facing wildlife management agencies today is recognition of the need for long-range planning for nongame wildlife species and their habitats and the community and ecosystem diversity they contain. Since history is replete with examples of common species driven to extinction through habitat loss, one would expect a sense of awareness or even urgency regarding this issue. Sadly, this is not the case. Perhaps the lack of a technology to measure and monitor the status of biodiversity over large expanses contributed to this apathy. Now, however, remote sensing and geographic information systems make the gathering and analysis of habitat information possible even for large or remote areas of the world (McNeely et al. 1990).

In cooperation with wildlife agencies in Idaho, Oregon, California and Utah, we are developing Geographic Information System (GIS) data bases that use satellite imagery to map the statewide distribution of wildlife habitats at a scale (1:250,000) that can be used for landscape-level planning and management. Areas as small as 200 acres can be mapped at this scale, and the amount of each vegetation type can be calculated. This provides a baseline from which to measure the effects of future land use changes. The degree of fragmentation of habitat types can also be calculated, and important wildlife corridors can be identified. This approach predicts the distribution of terrestrial vertebrates at a landscape scale by virtue of their habitat associations. For example, red-breasted nuthatches are predicted on a mountain side covered with lodgepole pine, but not on any particular tree. The locations of threatened, endangered or locally distributed species must still be tracked individually.

These data bases should considerably speed and simply the environmental impact review process, as well as aid in calculating cumulative impacts of changes in land use and land cover. Equally as important, negative effects of habitat fragmentation on area-sensitive species can be anticipated and, ideally, averted through planning and zoning actions. If wildlife habitats large enough to maintain populations of these area-sensitive species are maintained, smaller nongame species associated with those habitats should also be secure. The same methods can be applied to larger scale imagery (e.g., 1:24,000) to step down this approach to wildlife habitat management at the local or country level. We believe application of this methodology will lead to a proactive rather than a reactive approach to the loss of biodiversity, reducing the number of species that become endangered or extinct in the coming century (Scott et al. 1987, 1988, 1991, Davis et al. 1990). While GIS biodiversity data bases won't eliminate the need for field validation of distributions and field assessment of important sites, they will bring a valuable predictive tool to wildlife management—one that will help address the growing interest in nongame and wildlife.

The application of these tools to nongame wildlife management can change the challenge of preserving biodiversity from desperate struggles against extinction of single species to enlightened planning of future land use changes. Therein lies the greatest conservation and management opportunity of the last decade of the 20th century. It's up to managers to make use of it.

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Changing Social Profiles of Wildlife Recreation in Ontario, 1982–1988

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Introduction

People's use of wildlife resources in recreation activities has become the focus of a good deal of social scientific research. Research activity has recently shed light on less traditional aspects of wildlife use, including nonconsumptive uses such as bird-watching and indirect uses such as chance encounters of wildlife while hiking or skiing. Efforts to broaden the scope of enquiry concerning recreation wildlife use are welcome for at least two reasons.

It seems clear from the research that people count their involvements with wildlife as important elements in the quality of their lives. Without these involvements, their lives would be the poorer. In addition, the evidence that people participate in a great many other wildlife recreation activities beyond the traditional one, sport hunting, presents a profound challenge to natural resource managers responsible for wildlife. Setting goals for those wildlife programs must be broadened if agencies are to be responsive to what people desire when they take part in recreational activities involving wildlife.

This paper has as a general purpose the goal of contributing to a better and deeper understanding of recreational engagements involving wildlife. Using data from the 1982 and 1988 national surveys on *The Importance of Wildlife to Canadians*, conducted for the Canadian Wildlife Service by Statistics Canada, the paper seeks to examine the social dimensions of wildlife-related recreation in one Canadian province, Ontario, by identifying profiles of wildlife recreation.

Background

Identification of social profiles in wildlife-related recreation follows the trends established in outdoor recreation in general. Thus, Decker et al. (1987) presented a conceptual framework that emphasizes that wildlife recreation activity depends upon individual attitudes and preferences. Knopf (1983) provided ample evidence from the literature that recreationists not only are purposive in their behaviors, but that those behaviors are associated with sociological variables such as life-cycle, income, race and gender. Kellert (1983) showed that people's attitudes toward wildlife vary with sociological factors, such as age and education.

Method

Data

The surveys on which this paper is based were conducted for the Canadian Wildlife Service (CWS) and the provincial wildlife agencies by Statistics Canada. Since the surveys were conducted as part of regular Labour Force Surveys in February 1982, and in February 1988, the samples are large, comprising 76,201 Canadians in 1982 and 55,173 in 1988, from all 10 provinces (Statistics Canada 1985, Yiptong and Duwors 1990).

For the purposes of this paper, only information concerning values, expressed as degree of interest in wildlife recreation activities (e.g., hunting, watching wildlife) and socio-demographic variables was examined.

Analysis

Data analysis proceeded through three stages. In the first stage, cluster analysis (specifically, the "quick cluster" routine available in SPSS–X) was used to identify groupings in the data based on degree of interest. In the second stage of analysis, the groups produced by cluster analysis were tested by discriminant analysis to ascertain how well the cluster solutions allocated individual cases. After saving the groups resulting from the discriminant analysis, group membership in each year was used as a variable in chi-square analyses with socio-demographic factors.

Results and Discussion

Interest Groups

Cluster analysis was used to group Ontario respondents. Discriminant analysis, which was used to examine how well cases are allocated to clusters, revealed that 93 percent in 1982 and 94 percent in 1988 were classified correctly.

Table 1 presents four distinct groups from the 1982 CWS data for Ontario. The

Table 1. Wildlife interest groups in Ontario, 1982 (N = 12,821).

	Interest level[a]			
Variables	Group 1 (n = 1,837)	Group 2 (n = 9,528)	Group 3 (n = 805)	Group 4 (n = 651)
Watch wildlife	2.80	1.84	2.46	2.14
Feed wildlife	2.64	1.65	2.37	1.85
Collect specimens	1.29	1.06	1.20	10.5
Photograph wildlife	2.40	1.23	1.97	1.36
Hunt wildlife	1.21	1.07	2.45	2.12
Trap wildlife	1.11	1.01	1.81	1.19
Collect wildlife art	2.16	1.18	1.36	1.24
Become a member	2.08	1.06	1.38	1.51
Endangered species	2.36	1.23	1.48	2.35
Wildlife abundance	2.25	1.23	1.48	2.35

[a]3.0 = great interest; 2.0 = moderate interests; 1.0 = no interest.

data presented in this table are cluster centers for each variable in each group, where 3.0 denotes "great interest," 2.0 "moderate interest" and 1.0 "no interest." The larger cluster, Group 2, contains 9,528 cases, some 74.3 percent of the Ontario sample. This group, only moderately interested in watching wildlife, may be labelled "the public."

Members of Group 1, accounting for 1,837 respondents (14.3 percent), exhibit high interest in watching, feeding and photographing wildlife as well as in contributing to organizations working to protect endangered species. In addition, they are moderately interested in contributing to organizations working to ensure wildlife abundance, in collecting wildlife art and in becoming a member of wildlife-related organizations. This group, whose interests are nonconsumptive in nature, may be termed "the environmentalists."

The 805 (6.3 percent) respondents in Group 3 are highly interested in watching, hunting and feeding wildlife and moderately interested in photographing wildlife. This group may be labelled "the hunters."

Group 4, composed of 651 respondents (5.1 percent), is similar to Groups 1 and 3 in interests but differs in the strength of those interests. With relatively high interest in contributing to organizations which work for endangered species protection and for maintaining wildlife abundance, as well as more moderate interests in watching, hunting and feeding wildlife, this group is "the conservationists."

Table 2 presents four groups derived from the 1988 CWS data. Once again, there is one large cluster, Group 2, which comprises the majority (6,757 cases; 74 percent) of the cases in the Ontario sample. Once again, this group, "the public," exhibits a moderate interest in watching wildlife but is uninterested in other recreational activities involving wildlife.

With 918 (10.1 percent) members, Group 1 is highly interested in watching and feeding wildlife, in contributing to organizations seeking to protect endangered species, and to maintain wildlife abundance and in becoming members of wildlife-related organizations. Moderate interest is expressed in photographing wildlife and in collecting wildlife art. This nonconsumptive group is "the environmentalists."

Table 2. Wildlife interest groups in Ontario, 1988 (9,055).

	Interest level[a]			
Variables	Group 1 (n = 918)	Group 2 (n = 6757)	Group 3 (n = 341)	Group 4 (n = 1039)
Watch wildlife	2.73	1.89	2.56	2.88
Feed wildlife	2.44	1.68	2.28	2.80
Collect specimens	1.34	1.06	1.11	1.60
Photograph wildlife	2.27	1.28	1.60	2.42
Hunt wildlife	1.39	1.11	2.82	1.51
Trap wildlife	1.13	1.02	1.74	1.26
Collect wildlife art	2.21	1.18	1.37	2.06
Become a member	2.40	1.10	1.94	1.44
Endangered species	2.66	1.29	1.81	1.56
Wildlife abundance	2.59	1.25	1.84	1.53

[a]3.0 = great interest; 2.0 = moderate interest; 1.0 = no interest.

Table 3. Socio-demographic factor breakdown of wildlife groups in Ontario, 1982.

Variables	Group 1	Group 2	Group 3	Group 4
Gender	58% F	55% F	85% M	82% M
Age	40% 35+	57% 35+	36% 35+	40% 35+
Education	44% PS	28% PS	20% PS	29% PS
Occupation[a]	22% PRF	20% S&S	21% PRI	21% C&F
	20% S&S	20% NWF	21% C&F	20% S&S
	18% CLR	16% CLR	20% S&S	17% PRI
Marital Status	34% S	23% S	36% S	30% S

[a]PRF: Professional; S&S: Sales and Service; CLR: Clerical; NWF: Not in Work Force; PRI: Primary and Processing: C&F Construction and Fabrication.

Members of Group 3, numbering 341 people (3.8 percent), are highly interested in hunting and watching wildlife; they are also moderately interested in feeding wildlife, in becoming members of wildlife-related organizations and in contributing to organizations which seek protection for endangered species and which work to maintain wildlife abundance. These people are "the hunters."

Group 4, with 1,039 (11.5 percent) members, is highly interested in watching, feeding and photographing wildlife; members are moderately interested in collecting wildlife; members are moderately interested in collecting wildlife art. This group may be labelled "the naturalists."

Socio-demographic Factors

Chi-square analyses were conducted to determine if differences exist among the groups in terms of common socio-demographic variables such as gender, age, education, occupation and marital status. Not unexpectedly, with such large sample sizes, nearly all such analyses revealed statistically significant differences. The sole exception was with marital status which, in the 1988 survey, did not significantly differentiate the groups.

In the analysis of the 1982 data, gender, age, education, occupation and marital status markedly differentiate the four groups. Group 1, the environmentalists, is composed of a relatively high proportion of women, a sizable proportion of highly educated people (PS = at least some post-secondary) and primarily white collar occupations. In contrast, Group 3 (Hunters) and group 4 (Conservationists) are dominated by men, have lower levels of educational attainment (especially the Hunters) and feature blue collar occupations. Group 2, the Public, is composed of higher proportions of older people, married people and people not in the work force.

In 1988, the Environmentalists show many of the same characteristics as in 1982; however, a higher proportion are older and a higher proportion have at least some post-secondary education. Group 2, the Public, changes little from 1982 to 1988. Group 3, the Hunters, is almost wholly composed of men but maintains its blue collar occupational features. The emergence of the Naturalists (Group 4) is unexpected. It comprises a relatively high proportion of members with at least some post-secondary education and with white collar occupations.

Table 4. Socio-demographic factor breakdown of wildlife groups in Ontario, 1988.

Variables	Group 1	Group 2	Group 3	Group 4
Gender	54% F	54% F	92% M	55% F
Age	49% 35+	59% 35+	48% 35+	50% 35+
Education	52% PS	34% PS	34% PS	44% PS
Occupation[a]	22% PRF	20% S&S	32% PRI	21% C&F
	20% S&S	18% NWF	17% C&F	19% S&S
	16% CLR	16% CLR	13% S&S	16% PRI
Marital Status	28% S	24% S	28% S	27% S

[a]PRF: Professional; S&S: Sales and Service; CLR: Clerical; NWF: Not in Work Force; PRI: Primary and Processing: C&F Construction and Fabrication.

The changes from 1982 to 1988 suggest an aging and more highly educated population, the members of which share an interest in viewing wildlife but who, otherwise, differ in interests and in socio-demographic characteristics. Rising levels of education, rising ages and lower proportions of single people produce changes in wildlife recreation activity which are reflected in the nature of the groupings produced by the clustering technique. Increased interest in environmental issues is evident in 1988 in all groups except the largest, the Public. The decline in interest in consumptive activities produces two clearly drawn nonconsumptive groups of wildlife recreationists, the Environmentalists and the Naturalists.

The results reported here pose several challenges for public wildlife and natural resource management agencies in Ontario. The groups identified in the two years need to be better understood if their legitimate interests are to be met with wildlife programs. Agencies may have to decrease the traditional emphasis accorded to hunting as a program area. Finally, natural resource management agencies in Ontario must find the means to ensure that extensive information bases, such as the 1982 and 1988 CWS surveys, are incorporated into strategic and program planning.

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Cross-cultural Land Ethics: Motivations, Appealing Attributes and Problems

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Introduction

One of the more pressing problems facing wildlife and natural resource managers is the understanding and development of a land ethic among the various users of wildlands. The type and quality of land ethics held by the public is important because of the normative values, attitudes and behaviors practiced by the public have tremendous impacts upon the success of any number of wildlife and other natural resource programs (i.e., the presence or absence of poaching). Compounding the complexity of the land ethics issue is the profound influence that culture and ethnicity can play on the belief system and behaviors of the visiting public.

Land Ethics, Culture and Ethnicity

While a complex term, prone to interpretation, in this case, land ethics refers to a set of beliefs that serves to define the individual's value system relative to non-human objects. Callicott (1989:63) refers to land ethics as a governing system prohibiting or censuring as wrong certain modes of conduct affecting animals and plants. Leopold (1968) indicated that a thing was ethical if it preserved the integrity, stability and beauty of the biotic community, and was wrong when it did otherwise.

Understanding the concept of land ethics requires a consideration of the orientation, or predisposition, of individuals to the "community of life" which they are members. In addition, at the macro-level of interaction, the degree to which an individual's cultural and ethnic group identity supports and influences individual belief structures must also be considered. An individual may "belong" to a particular ethnic group but have little involvement and commitment to that group. Understanding the differences in land ethics will involve a close scrutiny of individuals and the larger group(s) they are influenced by.

Much of this understanding of land ethics is prone to individual interpretation which in turn is influenced by culture and ethnicity. Cultural groups are defined as collections of people who have developed unique norms of behaviors, goals, standards and expectations (Triandis 1983). In a similar fashion, ethnicity refers to group differentiation based on racial background or other cultural elements such as religion or language (Marger 1985, Van den Berghe 1976:242). Simcox and Pfister (1989) report that a number of cultural and ethnic factors can influence the development of a land ethic. These factors include religion, sense of place, social status, group normative behavior, economic background, perceptions of ownership, and the individual's achievement orientation. Many of these factors are outside the control of the individual wildlife or natural resource manager and yet can exert tremendous influence over the behaviors and actions practiced at the wildland site. Culture and ethnic background also serve to create differences in response and perception relative to issues such as stewardship of the land and interpersonal responsibility (Miller 1991:17). Consequently, an action that appears environmentally degrading to one individual or group (e.g., fishing-out a lake or stream) may appear reasonable and unexceptional by another.

Given the growing plurality of American society, it is surprising that relatively little research has been done on the effects of ethnicity and culture on land ethics. Hutchinson (1987) found that there were differences in park use patterns between Hispanics and Black-Americans, thus dispelling the myth that all minority groups were similar in recreation use patterns. In a more recent study on cross-cultural users, Noe and Snow (1990) found that the Hispanic user was ecologically attuned to the natural environment to the same degree that the non-Hispanic user was. Floyd and Gramann (1990) reported that with respect to the Mexican-American visitor, the greater the cultural and structural assimilation of the individual, the more similar the style and outdoor recreation participation were to Anglo-Americans.

Methods

To develop a greater understanding about the influence of ethnicity on the concept of land ethics, this particular study used place of birth as the surrogate measure for level of assimilation and acculturation. Following the work of Floyd and Gramann (1990), it was hypothesized that the closer to the United States the individual was born, the more closely that person would emulate the patterns of the dominant culture (e.g., U.S.-born Anglos). No value judgement was placed on whether this was a positive virtue. The underlying tenet of this hypothesis was that an overall individual land ethic would follow in the same direction as did the three study parameters: motivations, appeal and problems. In other words, the closer a Hispanic visitor's motivations, attributes for an appealing setting and perceived problems matched those of Anglo visitors, the more identical their land ethic would also be aligned (Noe and Snow 199).

Place of birth was selected as an appropriate surrogate measure for assimilation and acculturation using the logic that where a person is born encompasses a set of values about the attitudes, norms and beliefs collectively held about the natural environment and the biotic community. An individual's place of birth is an aggregate construct that captures many factors of interest to the natural resource manager, such as religion, sense of place, perceptions of ownership and trust in professional authority.

The Study Area

The study area consisted of approximately 1,000 linear feet of riparian corridor along the West Branch of the San Gabriel River on the Angeles National Forest in southern California. Visitors to the area tended to gather in well recognized but informally designated use sites along the river. Many of the sites contained flat sandy locations for cooking with access to deep pools for wading and shady areas.

Field Procedures

To study the three parameters of motivations, appeal and perceived problems, a questionnaire was distributed to individuals during the summer of 1989 (Simcox and Pfister 1990). Spanish-speaking enumerators were present to assist any visitors in understanding the instrument. Participants were asked demographic questions in addition to questions relative to why they were there (motivations), what did they like about the sites (appeal), and what environmental and managerial problems did they encounter (problems) while at the site.

Findings

Of a total of 837 potential respondents, 473 agreed to participate for a response rate of 56.5 percent of this group, 34.7 percent took English questionnaires and 59.6 percent took Spanish questionnaires. To the extent that formal education has an impact upon the development of a land ethic, the English only respondents had the highest level of education with 12.3 years. This was followed by bilingual Spanish-English respondents (11.5 years) and Spanish-only (8.9 years.

Motivations

The strongest motivations among all respondents for visiting the use site are related primarily to low levels of activity, escape, reduction of stress, and enjoyment of family and scenery. When compared to U.S. born Anglos, Hispanic motivational patterns focused on more passive, relaxed and cathartic motivations. As can be seen in Table 1, 13 of the 21 possible items achieved a significant different based on a five-point Likert scale. In this case, the proximity to the U.S. consistently produced values similar to U.S.-born Anglos suggesting that the closer to the U.S. an individual was born the more similar were their motivations for participation. Relative to the

Table 1. Motivational values based on place of birth.

Item	USA	USMH	MMH	CAH	P	Congruency[a]
View scenery	4.5	4.1	4.4	4.5	0.026	yes
Do some hiking	3.8	3.0	4.1	4.4	0.001	partial
Sunbathing	3.2	3.4	3.8	3.8	0.048	yes
Meet new people	2.3	3.4	3.8	3.8	0.001	yes
Get away from noise	4.4	4.0	4.3	4.6	0.012	no
View wildlife	4.2	3.6	4.3	4.5	0.001	no
Do some fishing	2.3	2.8	3.6	3.8	0.001	yes
Learn about nature	3.5	3.4	4.2	4.2	0.001	yes
Do some eating/drinking	3.0	3.7	3.8	4.1	0.005	yes
Be with family	4.2	4.1	4.4	4.6	0.032	yes
Discover new places	3.8	3.9	4.3	4.5	0.001	yes
Keep physically fit	3.6	3.5	4.2	4.4	0.001	yes
Experience new things	3.8	3.9	4.2	4.4	0.008	yes

[a]Congruency = Closer proximity to U.S., more similar to U.S.-born Anglo. USA = U.S.-born Anglos, USMH = U.S.-born Mexican/Hispanics MMH = Mexican-born Mexicans/Hispanics, CAH = Central American-born Hispanics means based on 1–5 point scale, with 1 = strongly agree, 5 = strongly disagree.

issues of fish and wildlife management, this linearity was applicable to doing some fishing and learning about nature but not apparent in viewing wildlife.

Appeal

When aggregated, the most appealing aspect of the visit among the respondents was being with the family (mean = 1.7, based on a seven point Likert scale with 1 = most appealing and 7 = least appealing). Again, when aggregated, the next four most appealing items were watching children play (2.2), water (2.2), preparing food (2.4) and shade (2.4). Upon considering the variable of place of birth, 11 out of 16 items generated significant differences. As illustrated in Table 2, with some exceptions, the closer to the U.S. the place of birth, the more similar the responses to the U.S.-born Anglo. This linearity of effect would suggest that specific wildlife attributes such as fish, birds and stream vegetation are more appealing to U.S.-born Anglos and Mexican/Hispanics than to those born outside the United States.

Problems

The third parameter of this study looked at the perceived problems as a function of ethnicity. In this case, when aggregate and based on a five-point Likert scale (with 5 = very serious problem), the top six concerns reported by the respondents were: litter on riverbank (mean = 4.1); litter in river (4.1); too few garbage can (3.8); inadequate toilet facilities (3.8); grafitti and vandalism (3.6); and water pollution (3.6). When disaggregated by place of birth, 11 out of 25 items generated significant differences. As shown in Table 3, there was a somewhat consistent pattern of response, based on the proximity of birth to the United States. Items considered particularly onerous by U.S. born respondents were grafitti, vandalism and water pollution. Items considered more problematic by foreign-born visitors when compared to individuals born in the U.S. were too few parking places, people breaking the law and people drinking alcohol. Relative to fish and wildlife, visitors reported no differences (based on place of birth) in their ability to see wildlife (aggregate mean = 2.4) and the presence of off-road vehicles (aggregate mean = 2.2).

Table 2. Appeal values based on place of birth.

Item	USA	USMH	MMH	CAH	P	Congruency[a]
Fish	3.9	4.1	2.9	2.7	0.003	yes
Other people	4.9	3.6	2.8	2.9	0.001	partial
Stream vegetation	3.9	4.2	2.1	2.6	0.001	partial
Watch children play	3.5	2.8	1.6	1.8	0.001	partial
Birds	3.5	2.7	2.1	2.3	0.030	partial
Prepare food	4.6	2.8	1.9	2.0	0.001	partial
Radios	5.9	3.5	3.2	2.9	0.001	yes
Wildflowers	2.5	3.7	2.5	3.6	0.005	no
Rocks	2.6	3.4	2.3	2.8	0.013	no
Lots of people	6.0	4.1	3.3	3.9	0.001	partial
Water equipment	4.9	3.1	3.7	4.1	0.009	no

[a]Congruency = Closer proximity to U.S., more similar to U.S.-born Anglo. USA = U.S.-born Anglos, USMH = U.S.-born Mexican/Hispanics MMH = Mexican-born Mexicans/Hispanics, CAH = Central American-born Hispanics means based on 1–7 point scale, with 1 = most appealing, 7 = least appealing.

Table 3. Mean values of perceived problems at recreation sites.

Item	USA	USMH	MMH	CAH	P	Congruency[a]
Too few parking spaces	2.7	3.0	3.4	3.4	0.034	yes
Grafitti and vandalism	4.4	3.8	3.3	3.6	0.001	partial
Water pollution	4.3	3.8	3.3	3.5	0.009	partial
People breaking the law	2.2	2.6	3.2	3.7	0.001	yes
Water level too low	2.9	3.4	2.3	2.7	0.001	no
Inadequate toilets	3.2	4.1	3.7	3.9	0.045	no
People drinking alcohol	2.4	2.4	3:5	3.6	0.001	yes
Mining the stream	1.3	1.9	2.3	2.6	0.001	yes
Not enough law enforcement	2.0	2.3	2.9	2.7	0.004	partial
Insufficient information	2.2	2.5	2.8	3.0	0.029	yes
Inadequate information service	1.9	2.3	2.5	3.2	0.001	yes

[a]Congruency = Closer proximity to U.S., more similar to U.S.-born anglos. USA = U.S.-born Anglos, USMH = U.S.-born Mexican/Hispanics MMH = Mexican-born Mexicans/Hispanics, CAH = Central American-born Hispanics means based on 1–5 point scale, with 1 = not a problem, 3 = moderate problem, 5 = very serious problem.

Implications

To the extent that place of birth serves as a surrogate measure of assimilation and ultimately land ethic, it would appear that, especially in the case of motivations, and to a lesser extent, appealing attributes, where a person is born has something to do with what they expect, want and how they might behave. As suggested earlier by Floyd and Gramann (1990), acculturation and assimilation can produce changes in behavior, attitude, and patterns of use. What the findings of this study suggest is that place of birth can serve as both an explanatory and predicting variable. To the extent that the data are generalizable to other situations and settings, the closer an individual's place of birth is to the United States, the more their motivations, appealing attributes and perceived problems will be similar to those reported by U.S. born visitors to wildland areas. Using this finding as the general framework, several implications for wildlife and other natural resource management areas emerge:

- There are no monolithic blocks of homogeneous ethnic groups. Rather, each ethnic grouping is composed of subgroups, each with different points of view and belief systems.
- Just as wildlife and other natural resources managers cannot assume that all Hispanics are alike in their motivations, appeal attributes and perceived problems, neither can it be assumed that they are all different from Anglo-Americans.
- Everyone has a land ethic, for resource managers the problem comes in when the visitor's land ethic is different from the accepted one. In essence, the problem is one of understanding what the belief system is and how to modify it if necessary.

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Public Views of Wolf Restoration in Michigan

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Introduction

Wildlife managers minimally depend on at least three major kinds of information. These include knowledge of the resource, the regulatory environment, and the needs and demands of society. Understanding the resource typically involves information on the biology, ecology and physical environment of species and their habitats. The regulatory context necessitates information regarding law, professional behavior, and organizational and administrative factors. Relevant societal information includes knowledge of socioeconomic structures, patterns of authority and property relations, and an understanding of the values and perceptions people attach to wildlife and the natural environment. This perspective of wildlife policy is described in detail by Kellert and Clark (1991) and is illustrated in Figure 1.

While an appreciation of the importance of societal information has expanded in recent years, this area still tends to receive relatively little systematic attention in the formulation and implementation of wildlife policy. This omission has resulted in frequent failures to achieve effective, efficient and equitable wildlife management goals and objectives. The historic experience of wolf restoration efforts in Michigan may represent an illustration of this omission of what has been called "human dimensions" information (Kellert and Brown 1984).

In 1974, an experimental reintroduction of the eastern gray wolf (*Canis lupus lycaon*) was attempted in Michigan's upper peninsula (Weise *et al.* 1975). Careful biological assessments and regulatory considerations had been conducted and most were confident that a viable population of wolves could be restored. Four wild animals were captured and released. Within nine months, all the animals were dead, their mortality primarily attributable to human-related causes.

No systematic attempt had occurred prior to the reintroduction effort to assess socioeconomic or valuation factors. Research by Hook and Robinson (1982) following the experiment revealed the critical importance of public attitudes as a major factor in the failure to reintroduce the wolf successfully. This research in particular identified two important attitudinal impediments: (1) an anti-predator attitude prevalent among critical elements of the rural populations; and (2) significant hostility and distrust of government programs seemingly imposed by distant regulatory authorities on local communities. Related research in subsequent years in Minnesota (Kellert 1986), Wyoming (Bath 1987), Yellowstone National Park (McNaught 1987), New Mexico (Briggs 1988), Montana (Tucker and Pletscher 1988) and elsewhere (Kellert 1990) have repeatedly documented the significance of socioeconomic and valuational factors as important information in wolf conservation and restoration programs.

In recent years, the eastern timber wolf has naturally recolonized areas of Michigan's Upper Peninsula. According to Wood (1991), "recent evaluation of reported

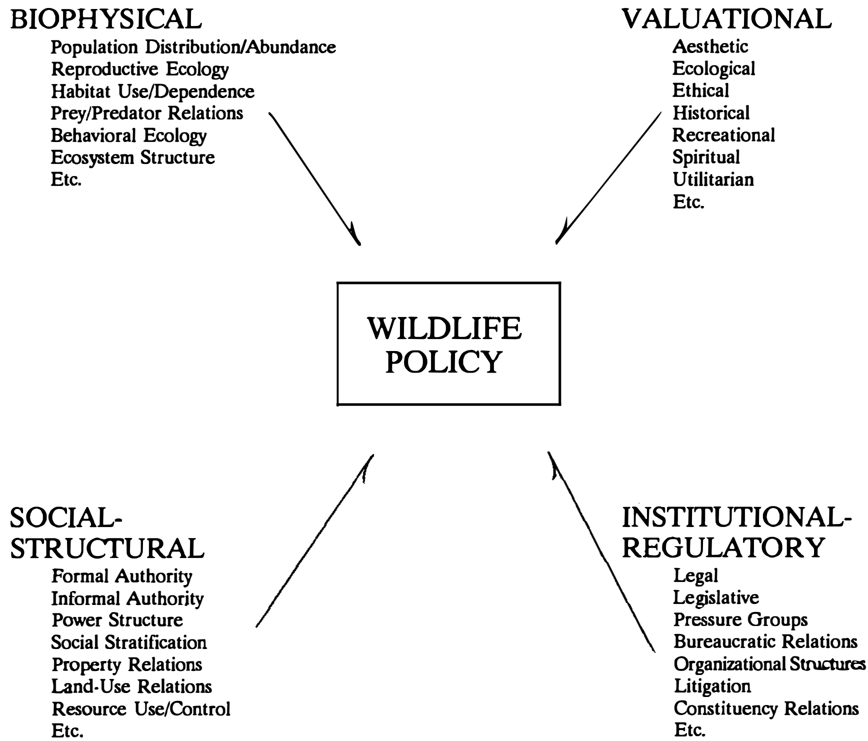

Figure 1. Major variable forces in the wildlife policy process.

sightings and track records indicate that . . . ten to twelve [wolves] are presently residing on the Michigan mainland."

Methods

The study reported in this paper was conducted in summer 1990, to provide human dimensions information to assist wolf restoration policy formulations and management efforts in Michigan. This research was sponsored by a consortium of public and private agencies including the U.S. Forest Service, Michigan Department of Natural Resources, National Park Service, U.S. Fish and Wildlife Service, the International Wolf Center, and the Sigurd Olson Institute. The author worked closely with HBRS, Inc. (a Madison, Wisconsin survey research firm), and particularly Dr. Tom Heberlein (a partner of HBRS, Professor of Rural Sociology at the University of Wisconsin and pioneer in the area of human dimensions in wildlife management).

A mail survey was completed by 639 adult Michigan residents covering attitudes, knowledge and behaviors toward wolves and this species possible restoration to the state's Upper Peninsula. Because roughly 97 percent of Michigan's residents reside in the state's Lower Peninsula, an oversampling occurred of Upper Peninsula residents. Special samples were also selected of critically important constituencies including deer hunters, trappers and farmers. Completed surveys were received from 69 percent of randomly sampled Upper Peninsula residents (N = 155), 61 percent of Lower Peninsula residents (n = 137), 75 percent of deer hunters (n = 113), 76 percent of trappers (n = 113), and 81 percent of farmers (n = 121). Deer hunters and trappers were randomly selected from lists provided by the Michigan Department of Natural Resources, while the livestock farmers sample was obtained from *Michigan Farmer Magazine*. Respondents completed a 22-page survey of approximately 150 questions. All contacted persons received an advance letter, initial survey mailing, a $2 incentive and, where appropriate, a thank you or reminder postcard, follow-up survey and reminder telephone call.

Results

The following results represent a portion of the findings obtained and the complete report can be obtained from the Michigan Department of Natural Resources (Kellert and HBRS, Inc. 1990). Considerable support occurred among all major sample groups, with the exception of farmers, for the restoration of the wolf to Michigan's Upper Peninsula. Deer hunters and trappers expressed the strongest support for wolf recovery. A majority of all groups, although significantly less farmers, endorsed the view that "if the wolf is restored to Michigan, government officials should do all they can to keep the wolf from going extinct again." Additionally, more than 70 percent of all primary sample groups—with the exception of a minority of farmers—supported the notion of reintroducing more wolves to the Upper Peninsula if needed. Among demographic groups, only the elderly, less educated and respondents of towns of 10,000–50,000 population revealed significant ambivalence regarding wolf restoration in Michigan.

Most respondents cited the wolf's existence and ecological values as the most compelling reasons for supporting wolf restoration (Table 1). The consumptive use and harvest values of the wolf, on the other hand, tended to be the least frequently cited reasons for restoring this species in Michigan. Farmers were significantly less likely than any other group to endorse the existence and ecological benefits of the wolf, while trappers were the most inclined to support the wolf's harvest value, and hunters this species' recreational and existence benefits.

Support for wolf restoration was often qualified when possible economic, resource and other land use impacts were considered (Table 2). A majority of most primary sample groups, for example, opposed taxes on large-scale development, or placing limits on human settlement in the Upper Peninsula, as ways of assisting wolf restoration. A majority of respondents, with the exception of hunters, supported the notion that valuable minerals, if discovered in the Upper Peninsula, would have to be developed even if it occurred in areas where wolves occurred. Only a minority of respondents supported closing or limiting road access to areas where wolves were found. Additionally, most groups endorsed the fear that "environmentalists" might use wolf restoration as "an excuse to . . . stop development in the Upper Peninsula." Finally, a majority of respondents supported limiting wolf numbers "if they became too numerous," with most groups favoring between 100 and 500 animals.

On the other hand, only a majority of farmers, trappers and less educated respondents objected to wolf restoration if it resulted in restrictions on commercial

Table 1. Mean scores[a] on items measuring reasons for wanting to reestablish timber wolves in Michigan.

	Upper Peninsula	Lower Peninsula	Hunters	Trappers	Farmers	F	Significance of F
Because they have a right to exist	1.9 (149)	1.6 (133)	1.7 (109)	2.1 (111)	2.7 (116)	20.2	0.000
So future generations can enjoy them	2.1 (151)	2.1 (133)	1.9 (109)	2.2 (113)	3.0 (118)	17.0	0.000
Because they are important members of the ecological community	2.3 (148)	2.0 (130)	1.9 (108)	2.5 (112)	2.9 (115)	14.7	0.000
To photograph them	2.5 (152)	2.4 (132)	2.3 (107)	2.7 (112)	3.3 (117)	13.8	0.000
Because we would be one of the few places in the United States with wolves	2.5 (149)	2.6 (133)	2.5 (109)	2.7 (113)	3.3 (117)	8.6	0.000
Because of their value to science and research	2.7 (152)	2.8 (132)	2.4 (107)	2.8 (113)	3.2 (116)	6.4	0.001
Because I am very fond of wolves	2.8 (152)	2.9 (133)	2.6 (109)	2.7 (112)	3.6 (117)	14.9	0.000
Because they may attract tourists	3.1 (149)	3.1 (131)	3.2 (108)	3.5 (113)	3.5 (118)	3.8	0.005
To be able to harvest their pelts	3.9 (151)	4.2 (130)	3.8 (109)	2.9 (112)	3.8 (116)	18.9	0.000
So that some people will be able to hunt them	3.9 (150)	4.2 (132)	3.7 (108)	3.4 (112)	3.8 (116)	7.7	0.000

[a]Mean score computed on a scale of 1 to 5 where 1 = "Strongly Agree", 3 = "Neither Agree nor Disagree" and 5 = "Strongly Disagree."

logging, and most respondents supported additional wilderness designations in the upper peninsula if it helped restore the wolf. A majority of the general public and hunters also favored restrictions on trapping, off-road vehicle use and coyote hunting in areas where wolves were found. Farmers, trappers and less educated respondents disapproved of these restrictions. A majority of trappers, farmers and, to a less extent, hunters believed that if enough wolves existed some could be harvested for their fur, although less than a majority of Upper or Lower Peninsula residents supported this view. Interestingly, most respondents feared that "any restriction of deer hunting in the Upper Peninsula to help restore the wolf" could threaten the future of hunting in Michigan.

Most respondents supported large fines and even prison sentences for the poaching of wolves. Additionally, a majority of respondents claimed knowledge of people who would be inclined to shoot a wolf if they saw one, although the great majority of respondents denied they would personally shoot a wolf if they saw one while deer hunting (although one-third of farmers did report this likelihood).

Regarding controlling possible wolf depredation of livestock, most respondents, with the exception of farmers, expressed strong preference for nonlethal control methodologies—particularly fencing, better husbandry practices, and live-trapping

Table 2. Primary sample group attitudes toward wolf restoration in Michigan, 1990.

	Upper Peninsula	Lower Peninsula	Hunters	Trappers	Farmers
I favor a tax on large-scale development in the upper peninsula as a way of obtaining funds to help restore wolves					
Strongly or moderately agree	23%	31%	30%	22%	12%
Strongly or moderately disagree	64	57	60	67	79
Neither agree nor disagree	13	12	10	11	9
	(151)	(132)	(110)	(111)	(116)
Rather than limit the number of wolves in the Upper Peninsula, I think we should limit the number of people who live there.					
Strongly or moderately agree	12%	8%	6%	19%	12%
Strongly or moderately disagree	80	84	90	77	82
Neither agree nor disagree	8	8	4	4	6
	(149)	(132)	(110)	(110)	(116)
If wolves are restored to the upper peninsula, I believe environmentalists will use this as an excuse to try and stop development there.					
Strongly or moderately agree	59%	40%	56%	72%	73%
Strongly or moderately disagree	33	36	31	18	16
Niether agree nor disagree	17	24	13	10	10
	(150)	(132)	(110)	(111)	(115)
I believe new mines would have to be developed in the Upper Peninsula if valuable minerals were discovered, even if it occurred in areas where wolves had been restored.					
Strongly or moderately agree	66%	58%	48%	66%	68%
Strongly or moderately disagree	16	18	33	22	13
Neither agree nor disagree	18	24	19	13	19
	(145)	(130)	(109)	(111)	(114)

and relocation. A majority of respondents did support the shooting or trapping of "individual wolves definitely known to have killed livestock."

Only a majority of trappers and farmers expressed the fear "that government officials want to restore wolves . . . to gain more control" over the Upper Peninsula. Most groups, however, preferred state rather than federal agencies be given the primary authority and responsibility for managing wolves in Michigan.

Most respondents strongly endorsed the wilderness and outdoor recreational importance of the wolf. All major sample groups, with the exception of farmers, additionally indicated the desire to visit areas where wolves could be found, as well as hear this animal howl in the wild. A majority of Upper Peninsula residents, trappers and especially deer hunters—although a minority of Lower Peninsula residents and particularly farmers—reported that "seeing a wolf would be one of the greatest outdoor experiences of [their] life." Despite this support for the outdoor recreational importance of the wolf, less than a majority of the respondents suggested the increased likelihood of visiting the Upper Peninsula because of the presence of wolves, or supported the belief that tourism to the area would grow as a consequence of wolf restoration.

The great majority of respondents strongly supported the maintenance of wolves in Isle Royale National Park if wolves began to disappear from the park. Additionally, most endorsed the view that "Isle Royale would no longer seem like a national park if wolves were no longer there." Finally, most objected to the notion of letting "nature take its course . . . if wolves . . . disappeared from Isle Royale National Park."

Knowledge of and basic attitudes toward the wolf were also explored. Thirteen true/false questions were used to comprise a knowledge of wolf scale standardized on a 0 to 100 scoring basis. As revealed in Table 3, trappers obtained significantly higher knowledge scale scores than did any other major sample group. Farmers had the second highest scores, while Lower Peninsula residents obtained the lowest knowledge of wolf scores (as well as significantly lower than found among Upper Peninsula residents). Nonsignificant knowledge scale differences occurred when comparing most demographic groups with the exception of significantly higher male than female knowledge scale scores.

When asked to estimate how many wolves currently existed in Michigan's Upper Peninsula, considerable variation occurred in the number cited. Estimates ranged from an average of 529 wolves among Lower Peninsula residents to 240 among deer hunters, 133 among farmers, 79 among upper peninsula residents and 62 among trappers. Despite the limited knowledge of the wolf revealed by the majority of respondents, especially the general public, most indicated the desire to learn more about wolf ecology, biology and behavior.

Six attitude toward wolf scales were constructed based on a factor analysis of

Table 3. Wolf attitude and knowledge scale scores of general public, hunters, trappers and farmers in Michigan, 1990.[a]

	Upper Peninsula	Lower Peninsula	Hunters	Trappers	Farmers	F	Significance of F
Humanistic	42.4	42.7	51.2	38.2	21.7	15.6	0.00
	(124)[b]	(121)	(100)	(102)	(102)		
Naturalistic	33.8	26.7	42.1	38.6	19.0	11.6	0.00
	(134)	(125)	(105)	(104)	(109)		
Negativistic	24.4	27.9	15.2	22.0	40.4	15.1	0.00
	(136)	(126)	(106)	(108)	(108)		
Dominionistic	23.5	17.0	30.7	54.4	34.4	38.6	0.00
	(132)	(120)	(99)	(104)	(105)		
Utilitarian	37.4	24.0	27.1	53.2	54.0	32.5	0.00
	(139)	(124)	(104)	(105)	(105)		
Ecologistic	44.9	45.6	54.2	48.3	30.1	10.4	0.00
	(130)	(121)	(104)	(106)	(104)		
Knowledge	56.5	47.4	54.2	67.8	60.2	28.2	0.00
	(143)	(129)	(106)	(108)	(108)		

[a]Mean scale scores constructed on a scale of 1 to 100.
[b]Numbers in parenthesis are number of respondents.

individual attitude questions. Scales consisted of 6–10 questions, with reliability analysis results indicating each of the six scales consisted of highly interrelated items. One sentence definitions of the six basic attitudes toward the wolf are as follows:

- *Humanistic*: Strong affection for the wolf and its existence value and protection.
- *Naturalistic*: Strong interest in direct outdoor recreational contact with the wolf.
- *Negativistic*: Strong fear, dislike or indifference toward the wolf.
- *Dominionistic*: Strong interest in mastery, control and dominance of the wolf, often in a consumptive use and sporting context.
- *Utilitarian*: Strong support for the utilization of the wolf, or subordination of wolf habitat for the practical benefit of humans.
- *Ecologistic*: Strong interest in the ecological value of the wolf, and its relationship to other species and the natural environment

Basic attitude and knowledge scale differences among the primary sample groups are indicated in Table 3. Significant differences occurred among the major sample groups on all seven scales. The distinctive attitudinal and knowledge profile of each of the groups is graphically depicted in Figure 2.

Deer hunters obtained the highest humanistic, naturalistic and ecologistic, and the lowest negativistic and utilitarian scale scores of any of the major sample groups. Hunters generally revealed the greatest affection, outdoor recreational interest and concern for the conservation of the wolf. Moderate dominionistic scale scores suggested hunters endorsed the right of humans to exercise mastery and control over the wolf, particularly in a sporting and recreational context. Relatively modest knowledge scale scores among hunters suggested their affection and concern for the wolf was relatively independent of any great factual knowledge and understanding of this animal.

Farmers expressed a very different view of the wolf. In contrast to hunters, farmers obtained the lowest humanistic, naturalistic and ecologistic, and the highest negativistic and utilitarian scale scores of any major sample group. Dominionistic scale scores were similarly high. Farmers thus revealed a consistent pattern of hostility and lack of sympathetic concern for the wolf. A legacy of antagonism and fear of the wolf appeared to be deeply ingrained among most farmers. Relatively high knowledge scale scores among farmers suggested that simply enhancing this group's factual understanding of the wolf would not likely result in more favorable attitudes toward this species or its restoration.

Trappers obtained the highest dominionistic and knowledge scale scores of any of the major sample groups. Trappers also had relatively high utilitarian, naturalistic and ecologistic, as well as low humanistic scale scores. This group appeared to be highly appreciative of the wolf's outdoor recreational and ecological value,but somewhat emotionally detached and strongly oriented toward human exploitation and dominance over this species.

Lower Peninsula residents obtained the lowest utilitarian, dominionistic and knowledge, and among the highest humanistic scale scores of any primary sample group. Lower Peninsula residents also had relatively high negativistic and low naturalistic scale scores. Residents of Michigan's Lower Peninsula thus appeared somewhat paradoxical in tending to express strong emotional affection for the wolf, yet considerable fear, as well as being relatively ignorant of this species biology and behavior. While often opposed to exploitation of the wolf, Lower Peninsula residents revealed little interest in this animal's outdoor recreational value.

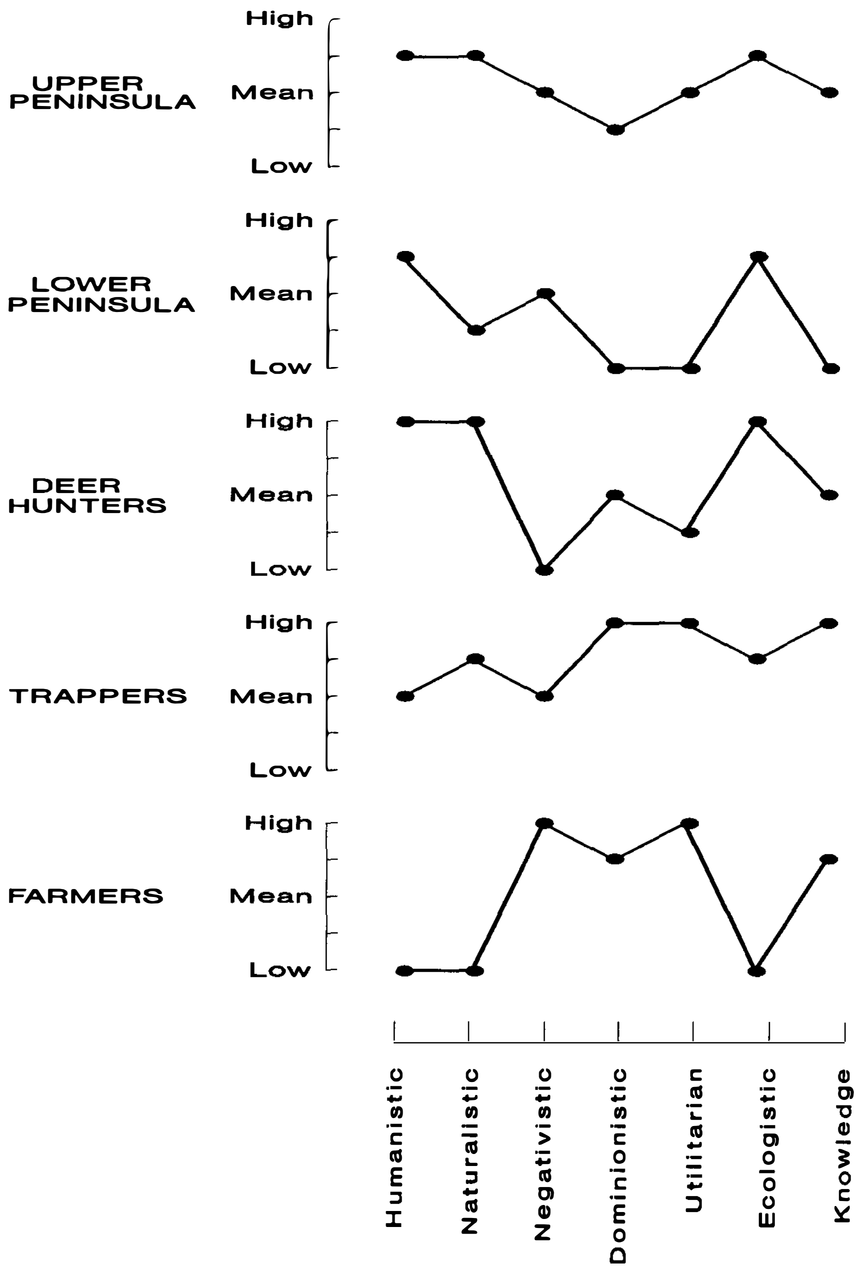

Figure 2. Relative wolf attitude and knowledge scale scores of general public hungers, trappers and farmers in Michigan, 1990.

Upper Peninsula residents obtained relatively high naturalistic, dominionistic, utilitarian and knowledge scale scores. Residents of the Upper Peninsula thus were significantly more interested in the wolf's outdoor recreational value, and more inclined to endorse its sporting and practical utilization, than were downstate residents. Upper Peninsula respondents revealed as much affection for the wolf as occurred among downstate residents, but with generally less fear and greater factual understanding of this animal.

Conclusion

Wildlife policy makers require information regarding the biophysical characteristics of the resource, the social structural features and wildlife values of communities and societal groups affected by management decisions, and an understanding of the legal mandates and organizational patterns associated with the institutional regulation of wildlife. This policy-making framework was illustrated in Figure 1.

This paper has presented information regarding the value and perceptual dimension—specifically, how major constituency groups in Michigan view the wolf and its possible restoration to the state's Upper Peninsula. Systematic consideration of this type of information could assist the likelihood of achieving effective (i.e., successful), efficient (i.e., least cost) and equitable (i.e., most likely to reduce conflict) wolf restoration policy.

The study found considerable support for the wolf and its restoration to Michigan's Upper Peninsula. Substantial appreciation and affection for the wolf was found among the general public, including most residents of the Upper Peninsula. Deer hunters revealed the greatest sympathy, concern, ecological appreciation and outdoor recreational interest in the wolf of any group examined. By contrast, farmers expressed the greatest antagonism and antipathy toward this animal and its conservation. The extent and consistency of anti-wolf views among farmers suggests this group may be highly resistant to change. Relatively hostile attitudes toward the wolf also occurred among the elderly and less educated groups in the general public.

Public awareness and education programs will certainly be an important aspect of efforts to promote more positive perceptions of the wolf. The findings of this study suggest, however, that knowledge and attitudes are often independent dimensions, and promoting greater factual knowledge of wolf will be an insufficient basis alone for achieving more sympathetic attitudes toward this animal or its restoration. While ignorance, misconception and misunderstanding of the wolf must be addressed, a more basic educational need will be to change attitudes of fear and hostility toward this animal.

The wolf possessed considerable outdoor recreational and wilderness appeal for many of the respondents. Relatively few, however, suggested the likelihood of travelling long distances just to be near wolves. Developing the wolf's tourism potential in Michigan's Upper Peninsula will require considerable cultivation before it can be expected to match the wolf's current attraction in Minnesota's Boundary Waters Canoe Area or Isle Royale National Park.

The relatively strong support for wolf restoration among a substantial majority of Michigan's residents appeared to be largely motivated by the existence, ecological and cultural values of the animal and only, to a limited degree, by its presumed harvest or consumptive use benefits. Despite support for wolf restoration, most respondents expressed strong reservations regarding extensive restrictions on human development and other economic activities to assist the wolf's recovery. Most respondents similarly expressed the ambivalent view that government should do all it can to assure the wolf's continued existence once the species had been reestablished, but limit wolf numbers if they became "too numerous."

The potential for conflict between wolves and Michigan residents appears to be greatest in the area of livestock management. Most respondents strongly preferred nonlethal control methodologies as the primary means for mitigating wolf-livestock conflicts or, when lethal control was necessary, focusing only on the offending animal. Moreover, the great majority of respondents favored relocation of problem animals.

Strong hunter support for wolf restoration is important to note and should be a critical element in any wolf recovery program. The historic role of sportsmen in Michigan wildlife conservation and management suggests this group could be a powerful ally in any broad-based effort to garner public support for restoring the wolf. Hunter support and affection for the wolf could constitute an important counterbalance to the antagonism and opposition potentially present among major segments of the agricultural community.

In conclusion, the result of this study strongly suggest proceeding with major effects to restore the wolf to Michigan's Upper Peninsula. A well-orchestrated and tailored restoration program, focusing on prevailing public attitudes and perceptions could, in contrast to the 1970s, result in the 1990s in successful restoration of this animal to its rightful ecological place in the wilds of northern Michigan.

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Managing Information About How We Are Managing: Multiple Perspectives on the Factors that Determine Agency Effectiveness

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Introduction

Crowe (1983) described a comprehensive management system consisting of a continuous feedback loop with four components—inventory (Where are we?), strategic planning (Where do we want to go?), operational planning (How do we get there?) and evaluation (did we make it?). Many agencies have discovered that employing this rational, explicit approach to agency management offers many benefits. Fish and wildlife agencies have traditionally emphasized the inventory components—generating information for fish and wildlife management. Inventory efforts are geared towards monitoring fish and wildlife populations, habitat and people who utilize fish and wildlife in various ways. However, fish and wildlife management, once a simpler combination of biology and law enforcement, is becoming increasingly more complex. Contemporary fish and wildlife management must consider social, economic, political and legal factors in addition to the traditional elements. As a result, the constituents (and adversaries) with which agencies must deal are changing rapidly. Former New York City mayor Ed Koch was known for asking his constituents, "How am I doing?" We believe the most effective fish and wildlife agencies in the future will be those that constantly ask the same question—and can consistently answer it.

In this paper, we focus on the inventory and evaluation components of Crowe's system as it applies to agency management. We discuss the specific factors that various groups involved in fish and wildlife management have identified as important in determining agency effectiveness and the priorities assigned to those factors. We present a conceptual framework for agency leaders to use in asking and answering the question, "How are we doing?"

Objectives and Approach

Our specific objectives were:

1. to identify the factors considered important in determining effectiveness of state fish and wildlife agencies from the multiple perspectives of numerous groups involved in fish and wildlife management; and
2. to rank the most commonly mentioned effectiveness factors.

To achieve the first objective, we met with a number of key groups to seek their opinions of what factors were important in determining agency effectiveness. The groups included state agency directors in all four regions of the country, American Fisheries Society Fisheries Administrators Section, Northeast Wildlife Administrators, Northeast Information and Education Administrators, Organization of Wildlife Planners and U.S. Fish and Wildlife Service Regional Federal Aid Supervisors. Whenever possible, we facilitated a discussion about the factors that determine effectiveness and recorded the results. When the time available was insufficient for a facilitated discussion, we briefly described the project and asked those present to write their ideas on a form we provided. A single list of factors was generated from the combined input of the various program administrators. Each of the other groups (including four regional groups of directors) produced independent lists of effectiveness factors.

Ranking of the identified effectiveness factors was achieved by condensing the multiple lists into a single list of the most frequently mentioned factors. The condensed list was mailed to 55 agency directors (including Puerto Rico, U. S. Virgin Islands, and two agencies each in Washington, Pennsylvania and North Carolina), 27 former agency directors, 60 fish and wildlife commissioners, and 32 state legislators serving on fish and wildlife or related committees. We asked each group to rate the importance of each factor on the condensed list on a scale of one to five. We also asked them to identify the five most important factors on the list (or factors they added).

Findings

Response rates to our requests to rank the effectiveness factors were 56 percent for legislators, 73 percent for commissioners, 89 percent for directors and 96 percent for ex-directors. With the exception of those for legislators, the response rates met or exceeded expectations for professional groups (see Dillman 1978). Response of legislators was probably affected by timing of the request (the mailings occurred during the 1990 election campaign).

Twenty-one of the factors fell into these six major groups: public support (including public awareness of agency programs and openness to public input), agency management (including leadership and management skills of leaders, participative decision-making, teamwork within the agency and internal communication), political factors (including agency credibility with the legislative and executive branches, sensitivity to politics, and relationships with other agencies), planning and funding (including adaptability and innovativeness, monitoring of societal trends, presence of a management system linking planning with budget allocation and amount, diversity and stability of funding), conflict resolution (including ability to resolve issues before conflicts arise, to resolve conflicts without appeal or override, and public perception of fairness in resource allocation and conflict resolution) and personnel factors (including definition of personnel roles, employee morale, employee recognition and rewards, and public and personnel understanding of agency mission). The remaining factor was status of animal populations and habitat.

The 22 effectiveness factors were ranked within each group of respondents for both the numeric (1–5) rating and the number of times a factor was identified as one of the five most important factors. Mean ranks were then determined across-respondent groups for each method. Three effectiveness factors (leadership and management skills, credibility with legislative and executive branches, and public support and satisfaction) topped both lists (tables 1 and 2). Four other factors (public aware-

Table 1. Rankings of 22 agency effectiveness factors (1 = highest rank, 22 = lowest rank) by state fish and wildlife agency directors (DIR), ex-directors (XDIR), fish and wildlife commissioners (COMM), and state legislators serving on fish and wildlife or related committees (LEG). Rankings are based on mean numerical responses of each group for each effectiveness factor on a scale of one to five (5 = greatest importance).

Effectiveness factors by functional areas	Rankings				
	DIR	XDIR	COMM	LEG	MEAN
Public support					
Public support for and satisfaction with agency	1	1	8	3	3.3
Public awareness and understanding of agency programs	6	8	1	5	5.0
Openness of agency to public input	8	10	13	3	8.5
Agency management					
Leadership and management skills of agency leaders	3	3	2	2	2.5
Participative decision making within the agency	14	15	17	16	15.5
Teamwork within agency	8	4	3	6	5.3
Internal communication	5	7	6	13	7.8
Political factors					
Agency credibility with legislative and executive branches	2	2	5	1	2.5
Sensitivity to politics	20	21	22	18	20.3
Relationship with other agencies	22	22	21	22	21.8
Planning and funding					
Adaptability and innovativeness in response to change	8	13	12	6	9.8
Agency monitors societal trends, looks towards future	12	17	14	15	14.5
Agency has management system in place linking planning and budget allocation	13	8	9	16	11.5

Table 1. (Continued)

Effectiveness factors by functional areas	Rankings				
	DIR	XDIR	COMM	LEG	MEAN
Amount, diversity and stability of agency funding	3	10	4	9	6.5
Conflict resolution					
Ability to resolve issues before conflicts arise	16	15	16	14	15.3
Ability to resolve conflicts without appeal or override	20	19	19	20	19.5
Public perception of fairness in resource allocation and conflict resolution	11	12	15	6	11.0
Personnel factors					
Definition of personnel roles	19	14	18	21	18.0
Employee morale	14	5	10	9	9.5
Employee recognition and rewards	18	17	20	19	18.5
Public and personnel understanding of agency mission	6	6	10	9	7.8
Ecological factors					
Status of animal populations and habitat	17	19	6	12	13.5

Table 2. Rankings of 22 agency effectiveness factors (1 = highest rank, 22 = lowest rank) by state fish and wildlife agency directors (DIR), ex-directors (XDIR), fish and wildlife commissioners (COMM), and state legislators serving on fish and wildlife or related committees (LEG). Rankings are based on the number of times each factor was selected as one of the five most important in determining agency effectiveness.

Effectiveness factors by functional areas	Rankings				
	DIR	XDIR	COMM	LEG	MEAN
Public support					
Public support for and satisfaction with agency	1	1	1	3	1.5
Public awareness and understanding of agency programs	11	11	4	5	8.0
Openness of agency to public input	4	6	10	1	5.3
Agency management					
Leadership and management skills of agency leaders	6	2	1	3	3.0
Participative decision making within the agency	12	17	17	12	14.8

(continued)

Table 2. (Continued)

Effectiveness factors by functional areas	Rankings				
	DIR	XDIR	COMM	LEG	MEAN
Teamwork within agency	9	10	8	9	9.3
Internal communication	12	17	12	12	13.5
Political factors					
Agency credibility with legislative and executive branches	2	3	3	1	2.3
Sensitivity to politics	19	21	20	19	20.0
Relationship with other agencies	21	21	20	12	18.8
Planning and funding					
Adaptability and innovativeness in response to change	5	11	10	7	8.5
Agency monitors societal trends, looks towards future	12	11	16	19	14.8
Agency has management system in place linking planning and budget allocation	8	4	9	12	8.3
Amount, diversity and stability of agency funding	3	4	6	7	5.0
Conflict resolution					
Ability to resolve issues before conflicts arise	16	14	12	19	15.5
Ability to resolve conflicts without appeal or override	19	17	17	12	16.5
Public perception of fairness in resource allocation and conflict resolution	9	7	12	5	8.5
Personnel factors					
Definition of personnel roles	18	14	20	19	18.0
Employee morale	16	9	6	9	10.3
Employee recognition and rewards	21	17	19	12	17.5
Public and personnel understanding of agency mission	6	7	12	9	8.8
Ecological factors					
Status of animal populations and habitat	15	14	4	12	11.5

ness and understanding, agency funding, understanding of mission and openness to public input) ranked in the top 10 of both lists. The five lowest ranked items were the same on both lists—definition of personnel roles, employee recognition, ability to resolve issues without appeal or override, sensitivity to politics and relationships with other agencies. The other 10 factors fell in the middle.

Agency directors rated public support for and satisfaction with the agency as the highest priority factor, followed by credibility with the legislative and executive branches, and agency funding, regardless of which ranking method was used. Not surprisingly, directors' rankings were most similar to those of ex-directors' (Spearman's rho = 0.84 for numeric rankings). Directors' rankings were similar to those of all groups. The only significant difference (defined as a difference between across groups mean rank and directors' rank of at least five) was that directors chose employee morale as one of the five most important factors less frequently than the other groups.

Ex-directors also rated public support and satisfaction, and credibility with the legislative and executive branches among the three most important factors. They differed from present directors, however, in ranking leadership and management skills among the top three rather than agency funding. Funding barely made the top ten on the ex-directors' list. Correlation of ex-directors' rankings with commissioners' and legislators' (0.75 and 0.77, respectively) were consistently lower than present directors' (0.81 and 0.85 respectively). Ex-directors differed significantly from other groups on only one factor—they chose internal communication as one of the five most important factors less frequently than other groups.

Commissioners had a distinctly different and sometimes inconsistent view of what is important in determining agency effectiveness. Commissioners' numerical rankings placed public awareness of agency programs, leadership and management skills, and teamwork within the agency at the top of the list. Their choices of the five most important factors were more in line with other groups, with public support and satisfaction, leadership and management skills, and credibility with the legislative and executive branches ranking highest. Commissioners' rankings consistently yielded the lowest correlations (0.81 compared with directors, 0.75 compared with both ex-directors and legislators). Commissioners' rankings differed significantly from other groups on several factors. In the numeric rankings, commissioners were the only group not to rank public support and satisfaction among the top three (they ranked it eighth). They ranked status of animal populations and habitat significantly higher than other groups by both ranking methods.

Legislators ranked credibility with the legislative and executive branches, leadership and management skills, and openness to public input as the most important factors by both ranking methods. Correlation of legislators' rankings were nearly as low as commissioners' rankings, but there were more outliers among legislators' rankings. In the numeric rankings, legislators ranked openness to public input and perception of fairness in resource allocation and resolution of conflicts higher than other groups. They ranked internal communication lower. Legislators chose ability to resolve conflicts without appeal or override, and employee recognition and rewards among the five most important factors more frequently than other groups.

Conclusions

Among the most significant implications of our investigation are the following:

1. agencies that want to monitor their performance need to collect information in areas outside of traditional animal population, habitat and resource user categories;

2. numerous respondents indicated all of the 22 factors on our list were important and would serve as a good starting point for assessing agency effectiveness; and
3. when the effectiveness factors are lumped into groups, highest priority was clearly attached to public support and awareness factors and agency management factors.

The effectiveness factors discussed here are broad indicators of agency effectiveness. Future investigations will be directed toward developing specific measures and methods that agencies could employ to monitor performance in the areas identified. Some agencies have already begun monitoring trends that affect their performance (Miles et al. 1990). Knuth and Nielsen (1989) and Knuth (1986) published lists of potential measures that could be used to monitor agency effectiveness.

The exceptionally high response rate to our requests for information (90 percent for agency directors) is just one indication of the amount of interest agencies have expressed in monitoring their performance. Clearly, agencies want to ask the question, "How are we doing?"

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Concluding Remarks

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My job today is to take you on a journey into the future. Apparently, someone thinks I can exercise some sort of supernatural skill and peer ahead to sagely advise, or at least foretell the future of data processing in fish and wildlife agencies.

Getting ready for this task, I got out my crystal ball and sat before my personal computer to put together this talk.

As I hammered the keys and peered into the crystal ball, I quickly came to the conclusion that the state of the art of crystal ball technology has lagged pitifully far behind that of personal computers.

I guess I could spend the next few minutes talking about advances in computer technology, but for wildlifers, the future does not depend on advances in computer technology. What's the sense of talking about forthcoming technology when we haven't begun to use what we already have today?

One thing my cloudy crystal ball tells me is that *if* we in the fish and wildlife business don't develop the capability to effectively manage data, we won't be in business very long. We are now directly in the path of an avalanche of the stuff, and if we don't capture it, channelize it, interpret it and use it properly, it will either run us over or the other guy will use it against us.

You don't need me to tell you that the opponents of fish and wildlife management, as we know it today, are becoming more sophisticated. Anti-hunters, with their growing demands that we prove our case for hunting certain species with well-organized data, are but one of our problems—perhaps the lesser one.

We need to amass and manage large amounts of data to determine what is happening to habitat or to support our position in our continuing siege warfare with "developers" and other entrepreneurs who believe they have better and higher uses for that little old stream in the hills that some trout call home.

Further, if we wish to retain our forest and waters, we are going to have to reduce them to their most common denominator—*money*—showing, if we can, that changing these waters or woods to accommodate the works of man may result in a net loss—not gain—of dollars and cents.

As the need to manage data grows—and if you think it has grown lately, you ain't seen nothing yet—you ought to look through my murkey crystal ball. We must improve our capability to meet the challenge.

This does not necessarily mean running down to the computer store for a new piece of equipment. What it really means is we—we managers— have to get smarter quicker.

One of the problems of this fish and wildlife business is we are not all that big, nor do we have a lot of money. This is not exactly the stuff that has the software honey bees buzzing around. Very little commercial software is created with our needs in mind.

We would be showing some symptoms of smartness if we—the states and the feds—would standardize all we can so our computers may talk to each other.

We will also overcome our lack of resources by pooling our talents to develop software that would be of mutual benefit to a number of states.

It would seem logical to recognize data processing as a discipline as important to our business as fish and wildlife biology. For example, we need to establish a clearing house to facilitate the exchange of software or expertise. In addition to developing data standards, it could also serve as a ''marriage broker'' between agencies—letting each of us know what software the other guy has, how it works and how we can go about sharing it. Further, this clearinghouse could set up partnerships for software development that would increase our buying power and make sophisticated systems more affordable.

Finally, my crystal ball sees a strong data processing presence in the proposed U.S. Fish and Wildlife Services Training Center—possibly at Harper's Ferry.

I have reached the point where the vertical hold on my crystal ball has started to slip. The only thing I know for sure is the future is out there and for us it is full of sharks. I truly believe that computers are important weapons in your arsenal.

I would hate to think that our future would be like that discussed by two old boys on the general store steps. They were both in their late eighties. One said, ''You don't hear a whole lot of talk about sex anymore.'' To which the other replied, ''I suspect it's still agoin' on—but there's a different crowd adoin' it.''

I hope it is our crowd that keeps on doing its best for fish and wildlife.

Special Session 3.
Imperatives of the Global Commons

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Cochair
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The Effects of Global Climate Change on Fish and Wildlife Resources

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In the last two years, the international scientific community has reached the consensus that global climate change will occur, if it has not already begun. This agreement culminates years of dispute about the rates, magnitude, and likelihood of global change, and is most strongly represented in the recent International Panel on Climate Change (IPCC) report (1990). The consensus has allowed resource managers the opportunity to stop debating whether global climate change will occur, and to focus instead on what the *impacts* of global change might be and what we can do about it: that is, what our *response* to global change should be.

As atmospheric and earth scientists have refined their global climate models, they have narrowed the range of potential scenarios. The IPCC scenario (Table 1) establishes probable conditions which can be used as the basis to review the impacts on fish and wildlife resources.

These changes are anticipated within the next 100 years— a short time biologically. The *magnitude* of change is large and the *rate* of change—about 10 times faster than climate change during the last interglacial warming—far surpass historic rates of change. In addition, this climate change represents only what is anticipated if CO_2 doubles; but without substantial changes in governmental policies, atmospheric CO_2 will continue to increase, and the climate may continue to respond by additional change.

It is also important to note that these are global averages. When we turn from global averages to the concerns of any particular geographic region, we are faced with three major limitations. First, the models' resolution are not sufficient to define

Table 1. The IPCC global change scenario.

• Atmospheric CO_2 will double by 2050
• As a result, by 2100, global temperature will rise 3°C
• Sea level will rise 0.6 meters
• The frequency and location of extreme events, such as storms, hurricanes, drought and heat waves, will increase
• Ultraviolet–β radiation at the Earth's surface will increase

local or regional impacts. To the extent they do, they often predict very different outcomes for what might happen at regional scales. These inconsistencies make applications at local and regional levels difficult. The second problem is that there is poor understanding of ecological relationships. The science of ecology, like the science of climate modeling, is not exact. This is further complicated when we deal with trends between competitors or predators, where the direction of the trend is similar but the magnitude of the change may differ. In such cases, we simply lack the ability to forecast outcomes, such as which species might have the competitive advantage.

A third major limitation in assessing the impacts of global change on geographic regions is the uncertainty of the human response. For example, the models are very consistent in predicting decreasing precipitation and soil moisture throughout the Great Plains States. One proposed response is a new network of irrigation and water delivery systems east of the Rocky Mountains. Thus, not only would a critical resource—water—decline, but also man's response would exacerbate the effect on fish and wildlife resources. In many cases *how* man responds to global change may have a more significant effect on the impacts on fish and wildlife than the rate or magnitude of global change itself.

Although we often refer to global warming, several kinds of change will cause impacts on fish wildlife and their habitats. Not only will atmospheric CO_2 and the average temperature increase, but also precipitation patterns and amounts may change. Many ocean currents and upwelling zones will decrease, coastal areas will flood, and biologically active wavelengths of sunlight (UV–β) will increase. The relative significance of each factor will vary according to geographic location.

Given this variety of expected results, we can identify a mixture of probable effects of global warming on fish and wildlife and their habitats. Clearly, some species will benefit. Cold-intolerant species, such as mangroves, manatees and many reptiles, will expand their ranges and possibly their abundance. Populations of arid land species will expand. Other species will be adversely affected. For example, cold-loving species, such as birch and trout, or interior wetland species, can be expected to decline. But clearly, the impacts will be far greater than just the biological consequences of higher temperatures. Table 2 summarizes a number of potential effects on selected resources. Although warming is what may well drive the changes, I believe the most significant impact on fish and wildlife in North America will be caused by other factors.

Based on these kinds of impacts, we have identified several kinds of resources that may be particularly sensitive to global change. These include selected ecosystems (coastal, old-growth forest, beech hardwood forests, aquatic), geographic regions

Table 2. Possible effects of global wanning on selected fish and wildlife resources of North America.

Resources	Effect	Cause
Coastal and estuarine ecosystems	• Net loss of wetlands and submerged aquatics	• flooding by sea level rise
	• Reduced productivity	• reduced nutrient inflow; reduced upland runoff and nearshore upwelling
	• Increased mortality of eggs and larvae	• increased UV–β
	• Temperature change will be less than global average	• oceans are heat absorptive
Great Plains	• Net loss of prairie potholes	• reduced precipitation and increased evapotranspiration
	• Temperature change will exceed the global average	• continental interiors are removed from ocean heat sink
Aquatic systems	• Reduced ice cover	• increased temperature
	• Increased thermal stratification	• increased temperature
	• Increased turnover time	• reduced inflow and increased stratification
Old-growth forest and mature climax communities	• Reduced biological diversity	• communities to develop
Vegetation	• Productivity may increase	• wanner temperatures and CO_2 fertilization
	• Productivity may decrease	• less moisture
	• Vegetation types may change	• C3 plants favored over C4 plants

(coastal, Great Plains, Arctic), and species (poikilotherms, endangered species and populations living at the fringe of their range).

Given our current imperfect understanding, I am most concerned about two large resource systems, coastal areas and the Great Plains. Both are examples of complex effects to be expected from global change, but they are affected by very different kinds of impacts. Because the oceans will serve as a heat sink, temperature change itself in adjacent coastal areas will be much less than the global average. Sea level rise will flood coastal habitats and may cause a loss of submerged aquatic vegetation and wetland habitats. The net effect will be highly dependent on the rate of change, but if sea level rises so fast that coastal marshes can not accrete vertically to compensate, a net loss of critical coastal marshes may occur. EPA models suggest the net loss will exceed 65 percent.

In addition, changes in nearshore currents are expected to reduce coastal upwelling zones along western continental margins, with a net decrease in nutrients and productivity (IPCC 1989). And UV–β is expected to be particularly damaging to many estuarine and coastal species with eggs, larvae or juveniles that float at the water's surface.

The Great Plains of North America also illustrate some of the more complicated effects. The Great Plains are a particularly useful example because of the unusual agreement among models about the types and amount of probable climate change. While there is great diversity among the models on the possible change of precipitation globally, the paleoclimatic record as well as many of the models agree in the Great Plains of North America: most of the models project a decrease of 30–50 percent in both rainfall and in soil moisture, especially during the growing season, for the Great Plains region (e.g., Schneider 1990; IPCC 1990).

Second, temperature change in the Great Plains will exceed the average global increase. The oceans will serve as a large heat reservoir and a moderating influence on global averages. The greater the distance from the oceans, the greater the temperature changes. In the mid-latitude, mid-continental areas of North America (that is, the Great Plains), a temperature change of 6° to 8° Celsius might be expected.

Third, man's response to these changes in the Great Plains, particularly in the form of competition for water for irrigation and increased groundwater withdrawal, will greatly exacerbate the global change effects on fish and wildlife resources.

Given these projections, several impacts on fish and wildlife resources in the Great Plains might be predicted. First, aquatic systems will be most severely affected. River and stream flows will decrease both in the volume of water flow and the duration or seasonality of flow. Water temperatures will increase, dissolved oxygen will decrease and groundwater recharged will decrease, exacerbating the effects of the present trend of increased water withdrawals for irrigation.

Second, I believe that wetlands and waterfowl will be the most severely affected resources in the Great Plains. One common example used to portray the effects of climate change in North America is the drought of 1988, when wetlands decreased in size, extent and duration, and waterfowl populations and breeding decreased significantly. These conditions mimic our best projections of a global warming scenario. Not only will the availability of water be reduced, but also the prairie pothole wetland complexes throughout the southern and mid Great Plains can probably not be reproduced in the northern part of the continent: the soil formation on the Canadian Sheild is not conducive to recreating the glacial-formed prairie potholes of the Great Plains.

Third, the diversity of aquatic invertebrates may decline. Invertebrates should be among the organisms best able to adjust to global change because of their short life cycle, their multiple generations in a season, and their size and ease of dispersal. These traits suggest they should be able to adjust the most readily to a rapid rate of climate change. But the relative distribution of freshwater and brackish wetlands will likely change, particularly as a result of declining recharge of shallow water aquifers. The prairie's brackish wetlands support a unique assemblage of invertebrates, and if those brackish wetlands are disproportionately lost, the diversity of invertebrate fauna (an important food resource to waterfowl and fish) will also decline.

Fourth, I believe there will be a net decline in the populations and distribution of fish and amphibians throughout the Great Plains region. It is surprising how many papers suggest fish will increase. These articles look at fish populations as strictly temperature-related, and suggest that as temperature increases, fish and amphibians, which are poikilothermic and are often cold-intolerant, will simply expand their range and increase their productivity. But the critical factor is whether temperature or the hydrologic regime is limiting. If the latter is true, which may frequently be the case in streams and ponds, then the reduction of water and wetlands, of river flows (in both amount and duration) and of water quality will lead to an overall decline in fish and amphibian populations, except in some of the larger, permanent lakes. Increased UV–β radiation may contribute to this effect. Many fish and amphibians have eggs or embryonic stages which are at or near the surface of the water, where they would be particularly vulnerable to increased UV–β radiation.

Fifth, productivity may decrease. Productivity depends on whether precipitation, temperature or carbon dioxide is the predominant factor limiting productivity in the Great Plains. Increased carbon dioxide increases productivity of some plants, but not all. Increased temperature will increase the growing season and lead to increases in productivity of some crops and some animal species. On the other hand, decreased precipitation will lead to a decrease in the overall productivity of some vegetation in the lower part of the Great Plains, especially areas devoted to the production of corn. In a drier climate, corn will likely be replaced by the production of wheat, which is far less productive in terms of kilocalories of carbon fixed, than is corn. I anticipate the same will happen to natural systems.

Sixth, community structure will change and biodiversity will decline. A common perception is that global warming will simply cause everything to migrate northward. While many species may migrate northward, the components of each community will migrate at different rates and with different abilities. There will be a loss particularly of old-growth forests or climax and late successional stages in many communities. Most communities will require time to develop in a new geographic location. Existing communities will disassociate as component species migrate at different rates. New communities will form, and their structure will change. Extinctions will increase, and biodiversity will decrease, at least in the geological short-term (the next 100,000 years). The reduction of biodiversity will largely reflect the rate of change, and, if the rate of global change were slow enough, communities probably could adapt and migrate. Another impact on communities will be increased habitat fragmentation. As species migrate northward or upward, communities will disassociate and become fragmented, with remnants left behind where once large refugia existed.

Seventh, *rapid* global change will lead to a higher extinction rate. Organisms can adapt if climate change is slow, but the IPCC scenario suggests a rate of change equal to any in the geological record. Man-induced extinctions today already surpass the historic "natural" rates. And scientists today predict a 100–1,000-fold increase in the rate of extinctions in the next 20–50 years (e.g., Wilson and Peters 1988). This increase is largely caused by habitat loss, and global change will exacerbate those losses, particularly for sensitive species with narrow habitat tolerance (e.g., Kirtland's warbler).

Eighth, the effectiveness of some existing protected areas will decline. Under the simplest scenarios, habitats will simply migrate; but as I have suggested, many habitat associations and communities will be lost. Existing refuges, parks and sanctuaries set aside to protect certain species and community complexes will lose their original value (although they will continue to provide some value as undeveloped, albeit different, habitats). Refuges in the United States, which largely protect wetlands, may experience a 50-percent reduction in the number of amount of wetlands they contain. Other areas which protect habitats for endangered species will lose their effectiveness as the species migrate. Both broad categories and site-specific locations of protected areas will lose their utility as refuges under global climate change scenarios.

Finally, let me provide some recommendations based on these observations and projections. First, we must establish effective monitoring programs for fish and wildlife resources. We must be able to define, monitor, understand and predict the impacts of global change on fish and wildlife resources. The U.S. Fish and Wildlife Service has initiated such an effort in FY 1991, as part of the U.S. Global Change Research Program. It will focus on systems, both coastal and Great Plains, where the effects of change are projected to be of the greatest consequences to fish and wildlife resources.

Second, we must identify and protect migration corridors and pathways for the natural redistribution of all species, to establish a new balance. Third, we need to develop new methods and programs to address habitat restoration. Fourth, we must develop new concepts and means for flexible habitat conservation programs. In the end, we should examine our concepts and approaches to conservation. Today's programs, too often designed simply as a static condition and to resist change, must be able to accommodate and anticipate change to be successful.

And finally, as professionals we must be open to change ourselves—change in the way we manage our resources, but also change in the possible interpretations we consider for the observations we make. Many biological events have already occurred which, although often attributed to other causes, should be reexamined in light of potential global warming: 11 years of near-record drought have contributed to a 30-year decline of mid-continent waterfowl. Forty species (about 10 percent) of the migratory birds in the Service's breeding bird survey have shown a statistically significant northward range extension over the past 30 years. Bird-sighting reports describe unquantified anecdotal northward range and breeding extensions of some shorebirds, such as black necked stilts and avocets (K. Stone personal communication: 1991), and the long-term northward range extension of armadillos is a part of wildlife folklore. Perhaps biota–as they were with DDT and other issues—will be our first real indicators of the onset and rate of global change.

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Assessment of the Risks from Tropical Deforestation to Canadian Songbirds

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Introduction

Half or more of the species of bird that breed in North America are long-distance migrants that spend two-thirds of the year in tropical South and Central America (Lovejoy 1983, Rappole et al. 1983), many of them in forest habitats. The rapid pace of destruction of tropical forests is one of the major environmental issues of our time (Whitmore 1975, Myers 1979, 1980, 1984, IUCN 1980, Allen 1980, Diamond and Lovejoy 1985, Murphy 1986). Most of the debate focuses on the global consequences—reduced bio-diversity, loss of genetic resources and climatic change—of the loss of this biome as a whole. But there are also likely to be significant direct effects on populations of Canadian migratory birds in the very near future, arising out of the serious reduction in the already very small amount of winter habitat available to them in Latin America; Myers (1980) estimated that 37 percent of Latin America's rainforest has already been lost.

Awareness of this problem has led to several studies of migrants in their Neotropical winter quarters, many reviewed and summarised by Keast and Morton (1980) and Rappole et al. (1983). Other studies have focused on trends in numbers and distribution of neotropical migrants on their breeding grounds in the eastern U.S., e.g., by Robbins et al. (1989) and, most recently, by Askins et al. (1990), who concluded that losses of winter habitat have lowered populations of neotropical migrants to the extent that they are becoming concentrated in the most favorable habitats, i.e., large tracts of continuous forest (Askins et al. 1990).

These studies, though frequently referring to "North America" as a whole, have mostly been carried out in the U.S. A Canadian approach to this problem is justified because:

1. the breeding habitats of these species are largely different in Canada from those in the U.S. (*viz.*, the predominance of boreal forest in Canada as compared with the U.S.), and are likely subject to different land-use pressures;
2. species that breed mainly in Canada would be neglected by studies in the U.S. (e.g., yellow-bellied flycatcher; Philadelphia vireo; Connecticut, Tennessee, Cape May, blackpoll, bay-breasted and palm warblers; gray-cheeked thrush) (Table 1);
3. survey schemes which monitor the populations of breeding birds successfully in the U.S. may not be appropriate to the much lower human population densities in Canada; and
4. the best data on population trends have come from long-term studies in deciduous forest of the eastern U.S.—there are no equivalent studies in Canadian forest.

This study assesses the likely importance to birds breeding in Canada of the continued decline in tropical forest. I ask the question "what is likely to happen to the area of winter habitat available to these species?'' not ''what has happened to the breeding populations of these species?''

Methods

The species pool (Table 1) represents those species in which half or more of the winter range lies south of the southern border of the U.S. and which, according to Rappole et al. (1983), occupy at least one woody habitat in winter. The habitats defined by Rappole et al. (1983) were matched as closely as possible with those used in the United Nations report on tropical forest resources (FAO 1981, Lanly 1982). Details of the reconcilation of the ornithologists' classification of habitats used by Rappole et al. (1983) and the foresters' definitions used by FAO are given by Diamond (1985, 1986). From these tables, the area of each type of woody habitat in each country was estimated, from which the proportion of its total winter habitat available to each species in each country of its winter range was calculated. To this quantitative description of the area suitable habitat in each neotropical country, the FAO estimates of deforestation rates were then applied, to calculate the proportion of the 1980 habitat area likely to remain in the year 2000.

It is important to stress that it is changes in bird *habitats,* not their *populations,* which are estimated. If each species occurs at the same density in all of its winter

Table 1. Canadian migrants to Latin American forest.

Species	Winter habitat[a]	Winter range[b]
Species breeding widely in Canada and wintering almost entirely within the tropics		
Broad-winged hawk (*Buteo platypterus*)	PB,G	S
Black-billed cuckoo (*Coccyzus erythrophthalmus*)	S	S
Chimney swift (*Chaetura pelagica*)	B,G	S
Vaux's swift (*C. vauxi*)	B	C
Eastern kingbird (*Tyrannus tyrannus*)	B,O,G	S
Great-crested flycatcher (*Myiarchus crinitus*)	PB,G	Cs
Olive-sided flycatcher (*Nuttallornis borealis*)	B,G	Sc
Eastern wood pewee (*contopus virens*)	C,B,S,G	S
Western wood pewee (*C. sordidulus*)	PC, PB	S
Yellow-bellied flycatcher (*Empidonax flaviventris*)	PB,G	C
Traill's flycatcher (*E. traillii*)	S, G	C
Least flycatcher (*E. minimus*)	S,O,G	C
Hammond's flycatcher (*E. hammondii*)	C,G	C
Rose-breasted grosbeak (*Pheucticus ludovicianus*)	C,B,G	CS
Black-headed grosbeak (*P. melanocephalus*)	C,B,G	C
Western tanager (*Piranga ludoviciana*)	PC, G	C
Scarlet tanager (*P. olivacea*)	PB, G	S
Red-eyed vireo *Vireo olivaceus*	PB, G	S
Philadelphia vireo (*V. philadelphicus*)	PB, G	C
Warbling vireo (*V. gilvus*)	C	C
Golden-winged warbler (*Vermivora chrysoptera*)	PB, G	SC
Nashville warbler (*V. ruficapilla*)	S, C	C

Table 1. (Continued)

Orange-crowned warbler (*V. celata*)	S,C,B,G	C
Tennessee warbler (*V. peregrina*)	PB,G	CS
Northern parula (*Parula americana*)	S,B,G	CI
Cape May warbler (*Dendroica tigrina*)	S,B	CI
Yellow warbler (*D. petechia*)	O,G	SC
Black-throated blue warbler (*D. caerulescens*)	S,B	CI
Magnolia warbler (*D. magnolia*)	PC,PB,G	CI
Chestnut-sided warbler (*D. pensylvanica*)	PB,G	C
Bay-breasted warbler (*D. castanea*)	PB,G	SC
Blackpoll warbler (*D. striata*)	PB	S
Blackburnian warbler (*D. fusca*)	PB,G	S
Black-throated green warbler (*D. virens*)	S,C,B,G	CI
Northern waterthrush (*Seiurus novaboracensis*)	G,M	SCI
Connecticut warbler (*Oponornis agilis*)	G	S
Mourning warbler (*O. philadelphia*)	G	S
Wilson's warbler (*Wilsonia pusilla*)	S,B,G	C
Canada warbler (*W. canadensis*)	PB	S
American redstart (*Setophaga ruticilla*)	S,B,G	SCI
Wood thrush (*Hylocichla mustelina*)	PB,G	C
Veery (*Catharus fuscescens*)	PB	S
Gray-cheeked thrush (*C. minimus*)	PB	S
Swainson's thrush (*C. ustulatus*)	PB	SC
Species with a substantial part (but less than half) of their wintering range in the southern U.S.		
Turkey vulture (*Cathartes aura*)	B,G	C
Yellow-bellied sapsucker (*Sphyrapicus varius*)	PC,PB,G	C
Whip-poor-will (*Caprimulgus vociferus*)	PC,PB	C
Ruby-throated hummingbird (*Archilochus colubris*)	B	C
Black-chinned hummingbird (*A. alexandri*)	S,O	C
Rufous hummingbird (*Selasphorus rufus*)	C,S	C
Calliope hummingbird (*Stellula calliope*)	C	C
Western flycatcher (*Empidonax difficilis*)	PC,PB,G	C
Dusky flycatcher (*E. oberholseri*)	S,G	C
Northern oriole (*Icterus galbula*)	B,O,G	Cs
Lincoln's sparrow (*Melospiza lincolnii*)	C,O	C
Violet-green swallow (*Tachycineta thalassina*)	C	C
Rough-winged swallow (*Stelgidopteryx ruficollis*)	B,G,O	C
Solitary vireo (*Vireo solitarius*)	PC	C
Black-and-white warbler (*Mniotilta varia*)	S,C,B,G	CSI
Yellow-rumped warbler (*Dendroica coronata*)	S,C,B	CI
Black-throated gray warbler (*D. nigrescens*)	C	C
Townsend's warbler (*D. townsendi*)	PC,PB	C
Palm warbler (*D. palmarum*)	B,O	CI
Ovenbird (*Seiurus aurocapillus*)	S,B,G	CSI
Common yellowthroat (*Geothlypis trichas*)	G,M	CI
Gray catbird (*Dumetella carolinensis*)	S,G	CI

[a]Winter habitat: P = primary, B = broadleaf, C = conifer, S = scrub, O = open (*savannah*), G = gallery, M = mangrove (from Rappole et al. 1983, Terborgh 1980).
[b]Winter range: C = Central America (including Mexico), S = continental South America, I = Caribbean Islands. Order of mention reflects relative importance; lower case symbols denote minor areas (from Rappole et al. 1983).

habitats, throughout its range, *and* if population size is limited by area of winter habitat, then changes in habitat would trigger changes in population size. But as Morse (1980) pointed out, we do not know whether the populations of neotropical migrants are limited primarily on the breeding grounds or in the winter quarters, and it is likely that there is a dynamic equilibrium between the limiting factors operating in the two major centres of a population's range. Nor is enough known of the relative densities of any species in different habitats throughout its winter. range, to correct for the differences in density which are a consequence of the habitat preferences which undoubtedly exist.

Results

Species at Risk

Sixty-six of the 79 species of birds that breed in Canada and winter in tropical forest are listed in Table 1. The 44 species that winter mainly in the tropics are distinguished from the 22 species whose winter range includes the southern U.S. Twelve other species that breed in Canada and winter at least partly in Latin America but reach the northern limit of their breeding range in extreme southern Canada are not treated further here, nor are a further 18 species that winter partly in Latin America but mainly in the southern United States. Table 1 also shows the major winter habitats and geographic range of each species, taken from Rappole et al. (1983), except for primary forest, which that study does not distinguish; these species are taken from Table 2 of Terborgh (1980), subtracting those species which Rappole et al. (1983) show as also occuring in scrub. Winter range shows whether a species

Table 2. Distribution type, habitat distribution diversity and deforestation under model 4.

Species	Distribution type[a]	H'[b]	Habitat area 1985[c]	Habitat area 2000	2000 as % of 1985
Turkey vulture	C	0.815	22570		45
Broad-winged hawk	S	0.888	223692	176324	78
Black-billed cuckoo	S	0.301	28110	32130	114
Yellow-bellied sapsucker	C	0.541	44272	26873	60
Whip-poor-will	C	0.459	9847	5777	58
Chimney swift	S	0.151	138452	107322	78
Vaux's swift	C	0.352	30598	12872	42
Ruby-throated hummingbird	C	0.513	56786	23424	41
Black-chinned hummingbird	C	0.000	72045	74745	104
Rufous hummingbird	C	0.000	20376	20959	102
Calliope hummingbird	C	0.000	17422	16994	97
Eastern kingbird	S	0.720	203594	158489	78
Great crested flycatcher	C	0.745	25243	12683	50
Olive-sided flycatcher	S	0.767	152125	93403	61
Eastern wood pewee	S	0.580	148623	123803	83
Western wood pewee	S	0.595	103631	73796	71
Yellow-bellied flycather	C	0.720	15860	6349	40
Western flycatcher	C	0.295	5516	2333	42
Traill's flycatcher	C	0.532	4362	5166	100

Table 2. (Continued)

Least flycatcher	C	0.222	57571	54832	95
Hammond's flycatcher	C	0.164	27411	25500	93
Dusky flycatcher	C	0.000	56196	58572	104
Northern oriole	CS	0.879	40687	19430	48
Lincoln's sparrow	C	0.155	33083	30789	93
Rose-breasted grosbeak	CS	0.642	173194	102925	59
Black-headed grosbeak	C	0.000	12757	7912	62
Western tanager	C	0.157	7118	5538	77
Scarlet tanager	S	0.516	65198	45596	69
Violet-green swallow	C	0.417	6055	4668	77
Rough-winged swallow	C	0.538	65743	28577	43
Red-eyed vireo	S	0.515	527759	439404	83
Philadelphia vireo	C	0.513	6642	1179	17
Warbling vireo	C	0.272	13361	11795	88
Solitary vireo	C	0.236	3842	2706	70
Black and white warbler	CSI	0.725	149034	132652	89
Golden-winged warbler	SC	0.595	23601	13709	58
Nashville warbler	C	0.060	102898	105412	102
Orange-crowned warbler	C	0.122	117335	43223	37
Tennessee warbler	CS	0.755	38202	22426	59
Northern parula	CI	0.455	35115	36441	104
Cape May warbler	CI	0.417	9482	9938	105
Yellow warbler[d]	SC	0.708	10037	10075	100
Black-throated blue warbler	CI	0.638	16455	15838	96
Yellow-rumped warbler	CI	0.409	103211	56379	55
Magnolia warbler	CI	0.653	26932	14277	53
Chestnut-sided warbler	C	0.631	18217	13423	74
Bay-breasted warbler	SC	0.394	18368	10352	56
Blackpoll warbler	S	0.863	108733	90057	82
Blackburnian warbler	S	0.586	73362	49072	66
Black-throated gray warbler	C	0.076	15254	14640	95
Black-throated green warbler	CI	0.565	88704	99111	112
Townsend's warbler	C	0.396	28889	17810	61
Palm warbler	CI	0.652	12783	6047	47
Ovenbird	CSI	0.825	80586	76222	95
Northern waterthrush[d]	SCI	0.992	4090	4090	100
Connecticut warbler[d]	S	0.201	1510	1510	100
Mourning warbler[d]	CS	0.900	660	660	100
Common yellowthroat[d]	CI	0.796	1849	1849	100
Wilson's warbler	C	0.292	113744	120331	106
Canada warbler	S	0.693	84876	61189	72
American redstart	SCI	0.915	233243	161084	69
Gray catbird	CI	0.305	28749	36722	128
Wood thrush	C	0.733	14904	8623	58
Veery	S	0.560	65908	51834	78
Gray-cheeked thrush	S	0.745	135266	107456	79
Swainson's thrush	SC	0.908	144366	107863	74

[a]Distribution type: C = Central America; S = Continental South America, I = Caribbean Islands.
[b]H′ = index of range and habitat diversity (see text).
[c]In thousands of hectares.
[d]These species are confined to gallery or mangrove forest, for which FAO gives no deforestation rates; their apparent stability is therefore spurious.

winters primarily in Central America (including Mexico), continental South America, the Caribbean Islands, or a combination of these major categories. These distribution patterns refer to the species as a whole; there are no data referring specifically to populations breeding in Canada. Such information could come only from banding recoveries, but there are far too few recoveries for this to be possible (Diamond and Brewer (in preparation).

Species Distributions

The habitats in which each species winters were tabulated, together with the countries in which they are known to winter. This basic database was modified for larger countries, to take account of the fact that few species winter throughout the whole country. Each species wintering in Mexico, Brazil, Colombia, Venezuela, Ecuador, Peru and Bolivia was given a weighting factor (from 0.1–1.0) according to the approximate proportion from the range maps in Rappole et al (1983) or Edwards (1972). The total area of each habitat occupied by that species in those countries was then multiplied by the weighting factor, to estimate the total area of habitat used by the species.

The simplest view of the overall distribution of Canadian migrants in tropical forest is the number of species of Canadian migrant wintering in each country, uncorrected for area of country or habitat (Figure 1). Seventy-five percent of Canadian species winter in Mexico, and there is a general decrease in number of species from north to south except for Belize, El Salvador and Guatemala, which all host fewer species than Costa Rica and Panama to the south. Colombia and Venezuela host more species than any other South American countries, and Brazil, despite its huge area, is relatively unimportant as a wintering site in terms of the number of species using it. Cuba and the Bahamas are the most important of the Caribbean Islands.

To remove the bias introduced into Figure 1 by size of country, the number of species wintering is divided by the total area of habitat used by migrants (Figure 2); this is a measure of the density of species per unit area of forest of migrants. This approach shows that the island of Hispaniola has the greatest number of species in relation to its forest area, and that other small countries—notably Belize, El Salvador, Costa Rica and Panama—host disproportionately high numbers of migrant species in relation to their areas of forest. By this measure, Mexico ranks as low as Bolivia and French Guaiana in its species density.

Figure 3 was compiled by summing over all species the total area of habitat used by migrant species, giving a figure equivalent to number of species times mean area of habitat available to each species. This total was then summed over all countries, and each country's total was divided by that overall total to give the proportion of the habitat-use by Canadian migrants throughout the neotropics that is accounted for by that country. This measure re-emphasises the importance of Mexico, as does Figure 1, but also gives Brazil and Colombia greater importance than previous treatments, because of the large areas of habitat which they contain.

None of these maps shows which countries are most "important" to Canadian migrants. Each shows a different aspect of "importance"; Mexico hosts more species than any other country (Figure 1), and also accounts for the highest proportion of total "species-habitat" use (Figure 3), but because it has so much habitat, the concentration of migrant species within it is much less than in many other countries with many fewer species but also very much less habitat (Figure 2). The largest

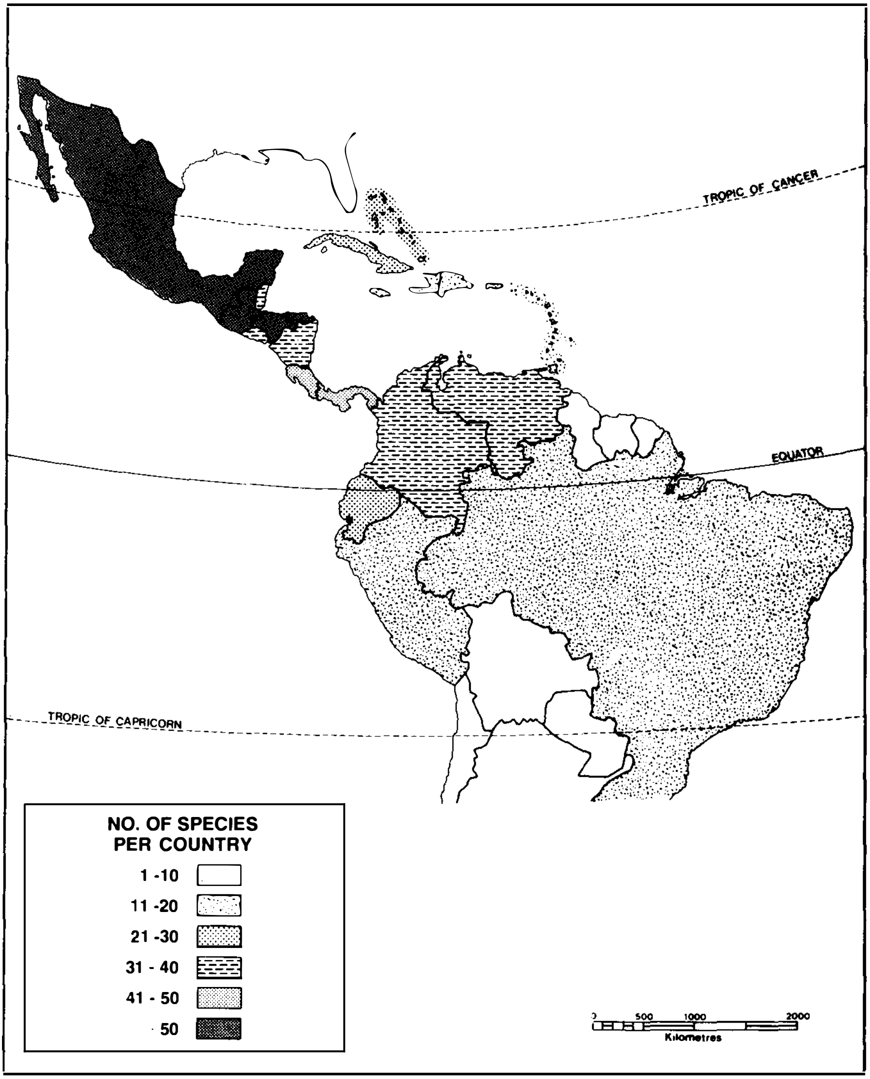

Figure 1. The number of bird species breeding in Canadian forest and wintering in forest in each country of the neotropics.

country of all—Brazil—is unimportant in terms of numbers of species (Figure 1), and hence in their concentration per unit area of habitat (Figure 2), but looms larger in Figure 3 where its enormous area of habitat is more clearly reflected.

Use of Habitat Types

The habitat which is used by most species (Table 1) is gallery forest (42 species or nearly two-thirds of all species). This is unfortunate because FAO gives no figures

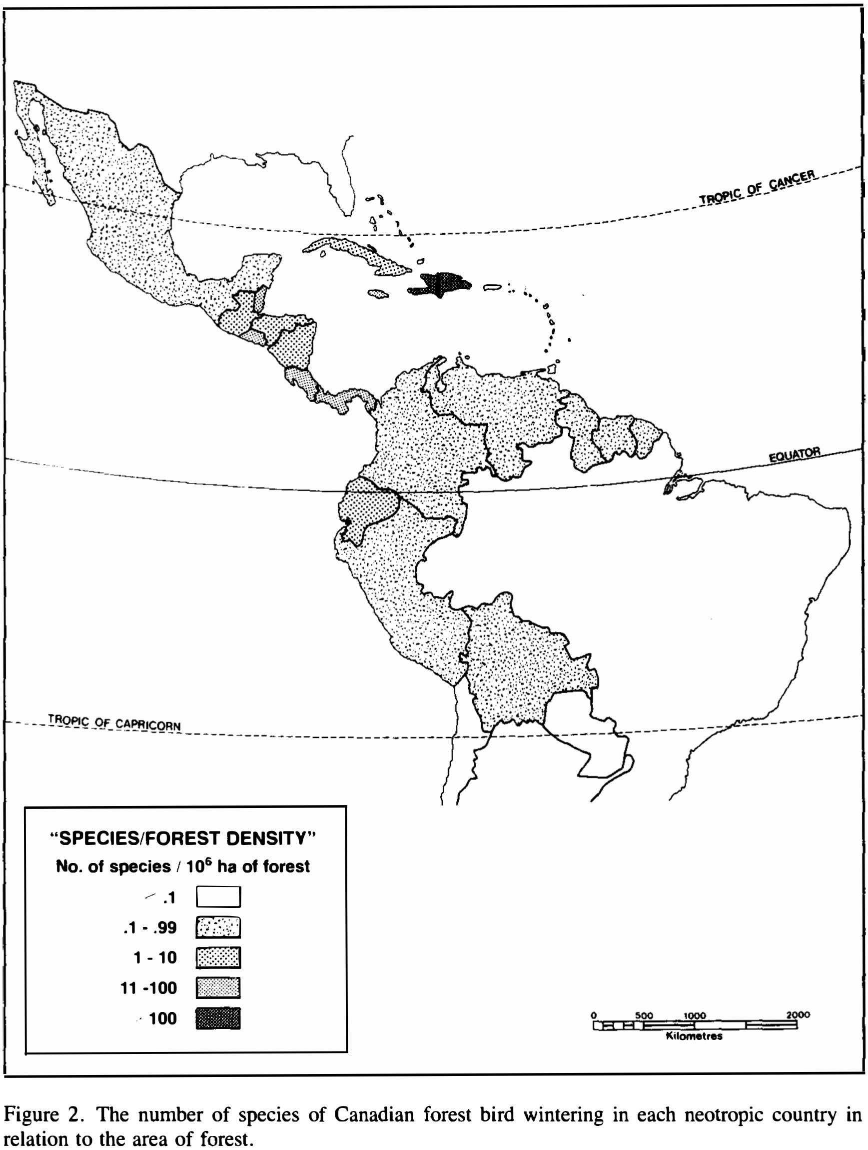

Figure 2. The number of species of Canadian forest bird wintering in each neotropic country in relation to the area of forest.

for the area of this habitat, nor for its rate of deforestation. Since it is an essentially linear habitat (along the edges of rivers) its total area must be relatively small.

Broadleaf and primary broadleaf forest are used by 21 and 23 species, respectively. Of these, five species occur *only* in primary broadleaf forest, and nine (including those five) only in primary forest (including conifers). Scrub is used by 19 species

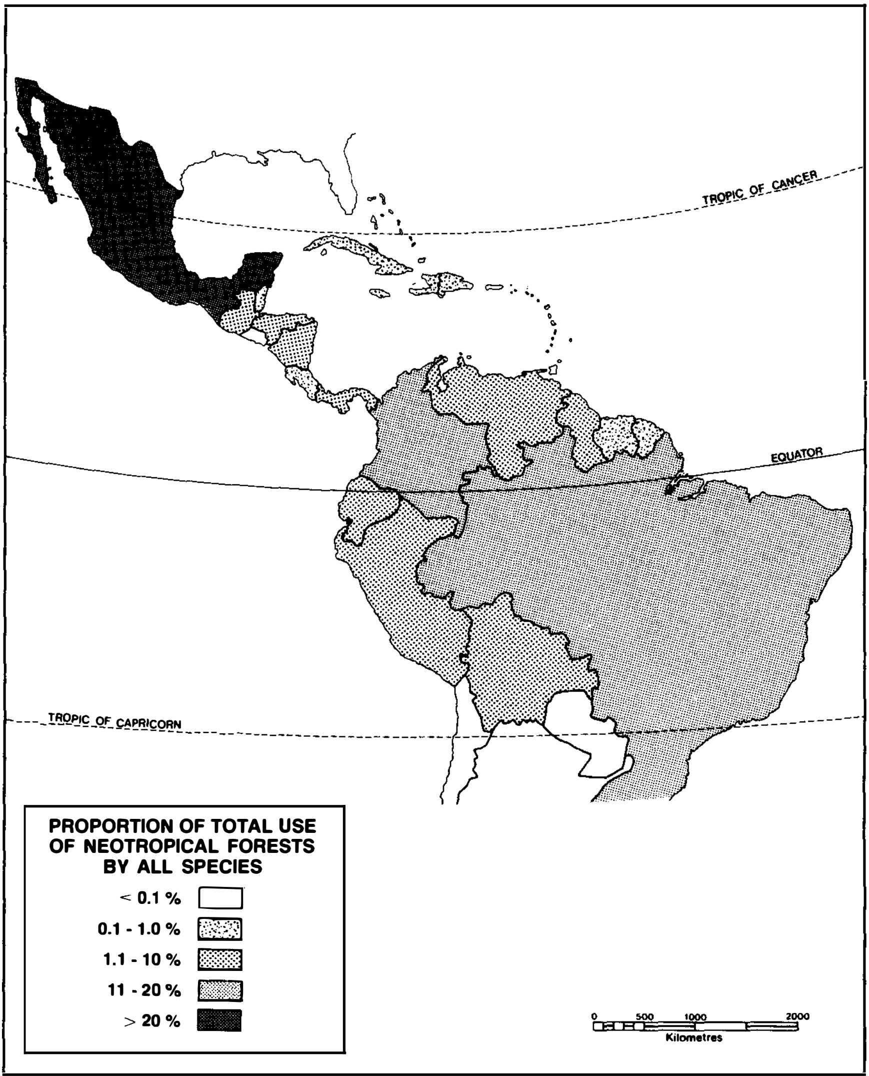

Figure 3. The proportion of total habitat use by migrant Canadian birds accounted for by each country of the neotropics.

(i.e., nearly as many as use broadleaf or primary broadleaf forest), savannah by 8 and mangrove by 2. Thus, many more species use secondary, scrubby or open kinds of broadleaf habitat than are dependent on primary broadleaf forest. Coniferous forest is used by 15 species, and primary conifers by a further 8, mostly in Mexico, often outside the strictly tropical zone.

Trends in Winter Habitat

FAO (1981) gave the only available estimates of deforestation rates that cover the whole neotropics and distinguish between habitats. I have amended these in various ways to counteract their intrinsic biases, which reflect the purposes for which they were drawn up (*see also* Diamond 1985).

Definition and Measurement of ''Deforestation''

FAO's interest in forest lies in its capacity to produce commercial timber. Consequently, their concept of 'deforestation' focuses on the alienation of forested land to some other land use. The chief form of deforestation which they measure is the transfer of forested land to agriculture. They specifically *exclude* logging because ''the selective logging that is practised in the large majority of tropical countries has a relatively slight effect on the forest'' (Lanly 1982).

However, the logging of previously uncut forest is of fundamental concern to the conservation of biodiversity, because it involves the loss of—or changes to—the only habitat category whose area can only be reduced, not increased, i.e., ''virgin'' or previously uncut forest. The areas recorded by FAO (1981, Table 3) as ''logged'' are very substantial, averaging 1.6 times the areas shown as ''deforested'' (FAO 1981, Table 6). In this study, I have added ''logged'' and ''deforested'' areas to obtain estimates of deforestation (in the conservation sense) for previously uncut forest categories.

FAO's estimates exclude not only logging, but also ''degradation'' due for example to overgrazing or collecting fuelwood (Lanly 1982). Myers (1980) pointed this out and included degradation in his estimates of forest ''conversion,'' but did not give separate figures for each country or habitat so his data cannot be used to correct for this bias.

FAO (1981) did not specify the methods used to estimate deforestation. Satellite imagery was incomplete and of recent origin at that time, so it cannot have played a large role in computing those estimates. They gave separate estimates of the area of each major forst type ''deforested,'' one for 1976–1980 and another predicted for 1981–1985. I have used the second of these figures, being more likely to apply to the period 1985–2000 of interest to this study. For forest types not included in FAO's deforestation tables, figures were derived by comparing their tables of areas of forest types in 1980 and 1985.

Models of Changes in Areas of Winter Habitat

Projections into the future, even from the recent past as in this case, are fraught with difficulties, especially when the past data are of uncertain reliability (as is true of deforestation rates in this case). An extra source of uncertainty arises from the root cause of changes to habitat, which lie in pressures on land caused by exponential increases in human populations—averaging 2.9 percent p.a. in Latin America as a whole (Myers 1980). Human populations in Latin America will average twice the size in the year 2000 that they were in the mid-1970s when the FAO data were collected. These uncertainties make it impossible to make firm predictions of future forest areas, or to assign confidence limits to such predictions.

The most appropriate approach to this problem is to make several different projections using different assumptions which are likely to ''bracket'' the real situation.

Here I make four such projections; in all cases, the database is the same, i.e., the areas of each forest type in each country in 1985 as predicted by FAO from measurements of areas existing in 1980. Despite their shortcomings, these are the only data which are available for the entire region in sufficient detail for the forest types described to be matched reasonably closely with the wintering habitats described by migratory birds.

Model 1. The extreme "best case" assumes that FAO's predicted changes in forest area between 1980 and 1985 will continue linearly to 2000, and uses FAO's own definition of "deforestation" (i.e., without correcting for logging). According to this model, total forest area in 2000 would be 95 percent of that in 1985, ranging from 73 percent in primary coniferous forest to 119 percent in secondary broadleaf and 118 percent in all secondary forest. Such changes would have trivial consequences for Canadian songbirds other than those which make extensive use of secondary forest.

Model 2. The extreme "worse case" uses measurements of deforestation in the Rondonia region of Brazilian Amazonia, made from LANDSAT satellite imagery between 1975 and 1983 (Fearnside and Salati 1985). This is a "worst" case because deforestation probably has proceeded faster here than anywhere else in Latin America (Fearnside 1986). During 1970–1983, deforestation in Rondonia increased from near zero to a cumulative total of nearly 6 percent (Fearnside and Salati 1985, Figure 1). The *mean* annual rate of deforestation over this period was 1.4 percent (*see* model 3), but the rate itself was still increasing between 1980 and 1983; if the virtually exponential *rate of increase* in the deforestation rate were to continue after 1983 at the same rate as previously, the forest would be cleared entirely by the year 1992. (Since deforestation rates in Rondonia are not given separately for different forest types, the same rate must be applied to all). The total loss of wintering habitat would obviously have catastrophic consequences for all neotropical migrants.

Model 3. If we assume that the Rondonia deforestation rate, instead of continuing to increase after 1983, remained at its average level over the previous decade (1.4 percent), then 80 percent of all forest types would remain in 2000; since the same rate is applied to all forest types, this model is not habitat-specific and so gives the same result for all species.

Model 4. A second intermediate model projects FAO's "deforestation" estimates linearly to the year 2000, but corrects them by including logging as deforestation; this gives new estimates for the area of habitat available to each species in the year 2000 (Table 3). They average about 72 percent of the 1985 area, but range from a decline of 83 percent for Philadelphia vireo to an increase of 28 percent for gray catbird.

Predicted areas of winter habitat are calculated only for model 4, because the other models yield estimates of areas which are either too trivial (model 1) or the same for all species (models 2 and 3). Model 4 is more useful because it is habitat-specific and so enables the consequences of habitat loss to be assessed separately for each species.

Future Trends

Table 2 presents several aspects of the winter distribution of Canadian neotropical songbirds, each with different implications for predicting future trends.

The distribution type—i.e., Central or South American, or West Indian—is not, by itself, a good predictor of the area of habitat in 2000 compared with 1985. Nor is an index of diversity (the Shannon-Weiner function $H' = \epsilon p_1 . \text{Log } p_1$, where p_1 is the proportion of a species' total winter habitat found in each habitat in each country [Tramer 1969]), which reflects the habitat and geographical specialization of a species of winter (a high value of H' showing low specialization); H' is slightly negatively correlated with the percentage of 1985 habitat remaining in 2000, but the correlation is not statistically significant.

The strongest relationship with relative loss of winter habitat proves to be with habitat type; species wintering primarily in primary forest can expect to retain, on average 62 percent of their 1985 habitat by 2000, compared with nearly 99% for species wintering in other habitats combined; this difference is highly significant (t–test, $p<.01$). This difference reflects not only the greater threats to primary forest than secondary, but also perhaps an underestimate by FAO of the rate of scrub clearance through neglecting to estimate the fate of 'forest fallow' (the vegetation arising from clearance of forest by shifting cultivation); the rate of clearance of this secondary vegetation is considerable, but unmeasured (Melillo et al. 1985).

It would be dangerous to conclude that species which use scrub in winter are not in danger. Although many migrants do make use of second-growth habitats in winter, many of those which do are immature birds behaving gregariously and as transients, while adults take up resident territories within mature forest (Rappole and Morton 1985). Further, scrub represents a stage in anthropogenic succession from mature forest to agricultural land, and back again as forest regenerates on abandoned land; but as human population pressure increases demands on the land, that succession will be arrested at progressively early stages, so that ultimately there will be very little left of either scrub or any other kind of forest. The increase in scrub and secondary forest which these figures suggest will occur between now and 200 is thus, at best, a breathing space for those species that use it; since the FAO figures may seriously overestimate the amount of these habitats this respite may be short-lived or even nonexistent.

Table 3 ranks each species according to several different measures of their vulnerability to habitat loss: the number of countries occupied in winter; total area of winter habitat available in 1985; the diversity of their winter range (H'), which combines the previous two measures; the area of winter habitat in 2000 as a percentage of the area in 1985, as predicted by model 4 of this study; and the unweighted mean rank of all these criteria. In each case, rank 1 is the most vulnerable, and so on.

The *number of countries* occupied gives a high rank to species—such as humingbirds—which winter no further south than Mexico, but also to others (black-billed cuckoo, Connecticut warbler, chimney swift) whose winter ranges are confined to small parts of continental South America.

The *1985 area of habitat* gives a different rank because so many species winter only in Mexico, which holds a large area of habitat. The highest ranks are confounded by the lack of data on areas of gallery forest; the most vulnerable species by this criterion include several that are restricted to this habitat, or it and mangrove (mourn-

Table 3. Species ranked according to number of countries used in winter, area of winter habitat available in 1985, diversity index, percentage of 1985 area of habitat predicted to remain in 2000, and combined mean rank.

Species[a]	Ranked According to 1985 area	Number of countries	Diversity index	2000 area as % of 1985
1. Connecticut warbler	6	2	13	[b]
2. Western flycatcher	6	7	18	5
3. Black-headed grosbeak	1	15	1	23
4. Solitary vireo	13	4	15	27
5. Philadelphia vireo	23	9	30	1
6. Western tanager	13	10	11	32
7. Vaux's swift	13	33	21	5
8. Bay-breasted warbler	13	24	22	14
9. Calliope hummingbird	1	22	1	50
10. Orange-crowned warbler	11	55	8	2
11. Violet-green swallow	13	8	25	32
12. Black-throated gray warbler	6	19	7	46
13. Whip-poor-will	23	12	29	15
14. Rufous hummingbird	1	25	1	57
15. Warbling vireo	13	17	16	42
16. Palm warbler	28	16	45	9
17. Hammond's flycatcher	13	31	12	44
17. Dusky flycatcher	1	39	1	59
19. Lincoln's sparrow	13	34	10	44
20. Black-billed cuckoo	6	14	19	65
20. Townsend's warbler	28	32	23	21
20. Traill's flycatcher	23	6	34	51
23. Chimney swift	6	57	9	34
23. Black-chinned hummingbird	1	45	1	59
25. Cape May warbler	13	11	25	62
26. Yellow-bellied flycatcher	40	20	49	3
27. Ruby-throated hummingbird	40	40	30	4
28. Golden-winged warbler	33	28	40	15
29. Nashville warbler	11	48	6	57
30. Scarlet tanager	23	42	33	25
30. Chestnut-sided warbler	28	23	42	30
32. Wood thrush	40	18	52	15
33. Veery	13	44	36	44
34. Turkey vulture	40	26	58	8
35. Mourning warbler	33	1	66	[b]
36. Yellow warbler	13	50	48	[b]
37. Rough-winged swallow	50	43	35	7
38. Yellow-rumped warbler	50	51	24	13
39. Yellow-bellied sapsucker	55	38	27	20
40. Black-throated blue warbler	28	21	43	49
40. Great crested flycatcher	48	29	53	11
40. Least flycatcher	40	41	14	46
43. Blackburnian warbler	33	46	39	24
44. Magnolia warbler	55	30	46	12

(continued)

Table 3. (Continued)

Species[a]	Ranked According to 1985 area	Number of countries	Diversity index	2000 area as % of 1985
45. Western wood pewee	28	52	40	28
46. Common yellowthroat	3	55	57	b
47. Northern parula	35	33	28	59
48. Canada warbler	49	33	47	29
49. Baltimore oriole	37	50	61	10
50. Tennessee warbler	36	50	55	18
51. Eastern wood pewee	59	23	38	40
52. Gray catbird	27	48	20	66
53. Wilson's warbler	54	33	17	63
54. Red-eyed vireo	66	40	32	40
55. Rose-breasted grosbeak	62	55	44	18
56. Gray-cheeked thrush	56	33	53	38
56. Northern waterthrush	5	65	65	b
58. Eastern kingbird	63	40	39	34
59. Blackpoll warbler	53	40	63	49
60. Olive-sided flycatcher	61	55	56	21
61. Black-throated green warbler	50	60	37	64
62. Swainson's thrush	58	61	63	30
63. Ovenbird	47	63	59	46
64. Black and white warbler	60	64	51	43
65. American redstart	65	66	64	25
66. Broad-winged hawk	64	61	62	34

[a]In order of mean overall rank.
[b]Species confined to gallery or mangrove forest, for which FAO gives no deforestation rates, so these ranks cannot be calculated; the mean ranks given here are those calculated from the first three columns only.

ing and Connecticut warblers, northern waterthrush). This bias is unlikely to be quantitatively very great because gallery forest covers relatively small areas.

The *diversity index* combines the previous two criteria; again, species confined to Mexico rank most vulnerable in spite of that country's large areas of habitat.

The *predicted area in 2000*, as a percentage of that in 1985, reflects vulnerability to expected future deforestation. The species ranking highest here are those whose winter distribution is predominantly in the isthmus of Central America, with only a small proportion in Mexico; these species sometimes (though not always) have small areas of habitat to start with, but the countries in which they occur are also experiencing the most rapid rates of deforestation. Thus, Canadian migrants as a whole show a similar pattern of vulnerability to that suggested by Fitzpatrick (1982) for the North American tyrant-flycatchers (*Tyrannidae*).

The 11 species ranking highest here, all of which are predicted to lose half or more of their winter habitat by the year 2000, are listed in Table 4, together with a further 20 species which are likely to lose between 25 percent and 50 percent of their winter habitat by 2000.

Table 4. Species of neotropical migrant birds predicted to lose most winter habitat by the year 2000.

Species	Percentage[a] loss by 2000
Species expected to lose 50 percent or more	
Philadelphia vireo	83
Orange-crowned warbler	63
Yellow-bellied flycatcher	60
Ruby-throated hummingbird	59
Vaux's swift	58
Western flycatcher	58
Rough-winged swallow	57
Turkey vulture	55
Palm warbler	53
Baltimore oriole	52
Great crested flycatcher	50
Species expected to lose between 25–50 percent	
Magnolia warbler	47
Yellow-rumped warbler	45
Bay-breasted warbler	44
Whip-poor-will	42
Golden-winged warbler	42
Wood thrush	42
Rose-breasted grosbeak	41
Tennessee warbler	41
Yellow-bellied sapsucker	40
Olive-sided flycatcher	39
Townsend's warbler	39
Black-headed grosbeak	38
Blackburnian warbler	34
Scarlet tanager	31
American redstart	31
Solitary vireo	30
Western Wood Pewee	29
Canada warbler	28
Chestnut-sided warbler	26
Swainson's thrush	26

Discussion

Loss of winter habitat need not translate linearly into lower breeding populations; the link between these two variables cannot be made until population densities and structure are known for each species and habitat. Such data would permit construction of a multiple-regression model relating density to habitat type, similar to that developed by Lofroth and Wetmore (1985) for forest birds breeding in British Columbia. However, it seems reasonable to proceed on the assumption that a species losing one quarter to one half of a winter habitat whose area has already declined substantially below earlier amounts, will experience a substantial population decline.

This study was intended to guide conservation activities as well as research; indeed, it has already done so, since it was useful to World Wildlife Fund Canada in designing and promoting their Meso-American Program, which now attracts around Can $1million a year (S. Price personal communication). It is important, therefore, at least to review the major causes of forest loss in Latin America, and outline some consequences of the expected population declines in songbirds.

Like most other conservation problems, this one is not intrinsically biological, but a by-product of interactions between people and their environments (Diamond et al. 1989, Diamond and Filion 1987). Forests are cut down in Latin America chiefly to provide land for agriculture, either cattle pasture to produce beef for export, or subsistence farming for landless peasants with no alternative because the best agricultural land is used to grow cash crops, also chiefly for export (Myers 1980, Lanly 1982). Both these patterns of land use are encouraged by development policies of foreign and multi-national corporations, as well as aid and development agencies, and by the social, economic and political policies of the governments of Central and South America.

The interrelationships among these human factors in habitat conservation in the tropics are beyond the scope of this paper, but it would be remiss not to draw attention to their importance. More detailed treatments can be found in Plumwood and Routley (1982), Mares (1986), and Shane (1986).

All the species concerned breed in Canadian forests, which are the country's largest single economic resource. Some species are known to play important ecological roles as predators of insect pests (e.g., the "budworm specialists"—Cape May, blackburnian, Tennessee and bay-breasted warblers [Erskine 1978]); others may play important but as yet unknown roles in forest ecology as pollinators, seed dispersers, competitors or predators. Forest birds are also important components of the country's wildlife resources whose non-consumptive exploitation has a major socio-economic impact throughout the nation (Jacquemot and Filion 1987). Thus the likely imminent decline in some of these species' populations may have significant repercussions on other components of the environment, and the national economy.

Finally, it should not be forgotten that these species face many threats other than the loss of winter habitat. Breeding habitat—particularly the more mature stages of forest—in Canada is widely exploited, or managed intensively, with scant regard for its role as migratory bird habitat. Current proposals to log large areas of northern Alberta must have very significant effects on the forest birds that breed there. Paradoxically, national data on deforestation rates are much harder to obtain for Canada than those for Latin America used in this study, and no attempt has been made to assess the effects of loss of breeding habitat on Canadian forest songbirds.

This paper is not intended to suggest that Latin American countries are solely—or even chiefly—responsible for threats to the habitats and populations of Canadian songbirds; rather, the intent is to demonstrate that the fate of "our" songbirds is a truly international problem, and that apparently remote conservation problems in distant and unfamiliar lands will likely have noticeable effects on our backyard birds. This in no way diminishes our responsibility to manage Canadian habitat for the benefit of these species; rather, it enlarges our responsibility to assist in resolving conservation problems throughout the western hemisphere.

Conclusions

1. More than half of the bird species that breed in Canadian forests and migrate to Latin America for the winter are likely to lose more than 25 percent of the winter habitat they had in 1985 by the year 2000, and 12 of these are expected to lose 50 percent or more.

2. The most vulnerable species winter mainly in the isthmus of Central America (i.e., between Mexico and Colombia), many of them chiefly in broad-leaved forest. Species inhabiting more open types of woody vegetation seem to be less immediately vulnerable, but the figures available for the areas of these habitats are serious overestimates.

3. The interpretation of the effects on breeding populations of these changes in winter habitat is hampered by inadequate data on the ecology and behavior of these species in winter.

4. Resolution of this issue will require a hemispheric approach to the conservation of migratory birds and their habitats, and much greater attention to problems in Latin America than is currently the case.

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Acidification: Implications for Wildlife

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Introduction

The acid rain problem is not a new one, having been described over 100 years ago in Europe (*see* Gorham 1989 for historical review). In North America, acid rain has been the focus of much research since the mid-1970s, when Likens and Bormann (1974) reported on the regional nature of the problem. It was soon evident that fish and other aquatic biota were being affected (e.g., review by Haines 1981), and wildlife managers began to be concerned that wildlife reliant on the aquatic environment for food and habitat were at risk (Clark and Fischer 1981, Haines and Hunter 1982). Since that time, a number of studies have been conducted on birds, mammals and amphibians to evaluate effects of acidification on aquatic-dependent wildlife. I will report on several of these studies, concentrating mostly on North American results, to illustrate the nature of the acidification problem for wildlife.

Effects of acidic deposition are not restricted to aquatic ecosystems. Though the precise role of air pollutants in forest declines is not clear (Bernier et al. 1989, Cox et al. 1989, Foster 1989, Johnson and Taylor 1989), there is increasing concern about long-term acidification of soils, increased metals and nutrient imbalances in forest ecosystems (Shortle and Smith 1988, Cronan et al. 1989, Federer et al. 1989, Foster et al. 1989). Few studies have yet been conducted on animals in affected forests, but there is some evidence reviewed here that wildlife are at risk.

Aquatic Environment

Amphibians

Aquatic life stages of many species of amphibians are known to be sensitive to acidity, and to the elevated concentrations of aluminum that are found in acidic ponds (e.g., Clark and Hall 1985, Freda 1986). An early study indicated that survival of spotted salamanders (*Ambystoma maculatum*) in meltwater ponds was reduced by pHs below 6.0 (Pough 1976). Additional studies have indicated a critical pH for egg and larval survival below 5.0 for most amphibian populations (Pierce 1985, Freda 1986). This indicates that they are less sensitive to acidity than are many species of fish and aquatic invertebrates.

However, these low critical pHs are not reason for complacency; Pough and Wilson (1977) estimated that one half of the species of frogs and toads in the United States, and a third of aquatic salamanders, breed in temporary pools. These pools are filled by spring meltwater and rain, and can be much more acidic than nearby lakes and permanent ponds (Pough and Wilson 1977); Freda (1986) showed that 5 to 81 percent of ponds surveyed in several studies had a pH under 4.5, within the critical pH range of amphibian species. Not surprisingly, surveys of amphibian distribution have typically observed an avoidance of the most acidic habitats for breeding (*see* review by

Freda 1986). Regional surveys of water chemistry, and models of biological damage that are based on those surveys (e.g., Schindler et al. 1989, Minns et al. 1990) have tended to neglect the small aquatic habitats used by many amphibians, and therefore may underestimate the extent of aquatic damage from acidic deposition.

Birds and Mammals

Birds and mammals are not likely to be directly affected by acidity of the aquatic environment. Instead they are affected indirectly, through changes in habitat or in the quality or quantity of available food. This has made efforts to demonstrate impacts of acid rain on wildlife more difficult, and probably explains the low number of studies that have been conducted, relative to studies of wholly-aquatic animals.

Habitat change. Aquatic plant communities are influenced by acidity and metal concentrations (Wile and Miller 1983, Ormerod et al. 1987, Arts and Leuven 1988, Arts et al. 1990). Because plants are important as food and cover for a variety of birds and mammals, there has been speculation that the effects of acidity on aquatic plants may have implications for wildlife (Clark and Fischer 1981, Haines and Hunter 1982). With the exception of a study by DesGranges and Houde (1989), which showed that aquatic plant communities are one of several variables that affect habitat selection by birds, this link has received little attention in acid rain studies.

Food quality. A major concern for wildlife has been that metals (especially aluminum, cadmium, lead and mercury) will be at elevated concentrations in prey from acidic environments, potentially resulting in metal toxicity for consumers. Nyholm and Myhrberg (1977) observed impaired reproduction (reduced eggshell quality and hatching success, lower clutch size, and increased female mortality) among songbirds nesting near remote lakes in Sweden. The phenomena appeared to be related to aluminum accumulation (Nyholm 1981), presumably obtained from a diet of emergent aquatic insects. However, there is little published evidence to suggest that aquatic insects have higher aluminum content at low pH (Ormerod et al. 1988), despite much higher aqueous aluminum concentrations in acidic lakes and streams. Nor has there been evidence of similarly impaired reproduction among North American birds breeding near acidic lakes (but see below for terrestrial wildlife).

Recently, controlled experiments with breeding birds have demonstrated that dietary aluminum can impair reproduction in birds when levels approach calcium and phosphorus concentrations in the diet (Carrière et al. 1986, Sparling 1990). Breeding birds, especially females that require calcium for egg-laying, accumulate certain metals from their diet more efficiently when dietary calcium levels are low (Scheuhammer 1991). This is of concern to wild birds because sources of dietary calcium are greatly reduced in acidic environments (Økland and Økland 1986, Scheuhammer 1991). In fact, low dietary calcium itself may be a factor contributing to reduced clutches and decreased growth of birds near acidic waterbodies (Ormerod et al. 1991, Blancher and McNicol 1991). The best evidence for this mechanism comes from studies of the Eurasian dipper (*Cinclus cinclus*), a passerine that relies on stream invertebrates for food. This birds shows reduced serum calcium levels in adults and nestlings, thinner eggshells, and lower clutch size and nestling growth when breeding along acidic streams (Ormerod and Tyler 1987, Ormerod et al. 1988, 1991).

Scheuhammer (1991) reviewed the literature on dietary metal exposure to wildlife in acidic environments and concluded that cadmium and lead levels are sufficiently low that risks to wildlife health and reproduction are unlikely. Nevertheless, cadmium concentrations in the livers and kidneys of moose, deer and caribou can be high enough to pose possible health risks to human consumers (Crête et al. 1987, 1989, Glooschenko et al. 1988, Wotton and McEachern 1988, Brazil and Ferguson 1989). There is some evidence to suggest that tissue cadmium levels are higher in acid-sensitive regions, where cadmium may be more available in plant food (Crête et al. 1987, Glooschenko et al. 1988). However, there is a need to sort out the extent to which elevated cadmium in ungulates reflects acidity as opposed to local pollution, atmospheric transport or natural variations in cadmium availability (Brazil and Ferguson 1989, Scanlon et al. 1986, Steinnes 1989).

Mercury concentrations in fish are known to be elevated in acidic lakes (e.g., Scheider et al. 1979, McMurtry et al. 1989, Wiener et al. 1990, Spry and Wiener 1991). This has important toxicological implications for fish-eating wildlife such as mink or loons as they can be affected by dietary mercury at concentrations of less than two ppm per weight (*see* reviews by Wren 1986, Scheuhammer 1987, 1991). The common loon (*Gavia immer*) may be at particularly high risk because its reproduction is affected when mercury in fish is as low as 0.3–0.5 ppm (Barr 1986), and these mercury levels are observed in small fish from acidic lakes (cf. Scheider et al. 1979). Mercury in tissues of fish-eating birds and mammals from acid-sensitive regions are known to reach levels observed in mercury contaminated watersheds (Wren et al. 1986, Eriksson et al. 1989, Scheuhammer 1991), raising concern for the health of these animals. Unfortunately, "studies designed specifically to determine Hg-related reproductive effects in piscivorous birds and mammals living in acidified habitats have not been undertaken, nor have specific surveys to determine Hg concentrations in prey of an appropriate size and species composition" (Scheuhammer 1991).

Prey availability. The mechanism that has received the most attention from wildlife researchers interested in the effects of acid rain has been the potential for a reduction in food abundance resulting from acidification. The loss of fish from acidic lakes and rivers was noted early on (e.g., Beamish and Harvey 1972, Schofield 1976) and has obvious implications for fish-eating mammals and birds. Otters, osprey, loons and mergansers have been shown to avoid acidic habitats or show reduced reproduction there (Mason and Macdonald 1989, Eriksson et al. 1983, Alvo et al. 1988, Wayland and McNicol 1990, Blancher et al. 1991), though this is not always the case (Eriksson 1987, Parker 1988).

Since fish species differ in their tolerance to acidity, acidification of lakes or streams often results in only a partial loss of fish species, and may not reduce the total biomass of fish (Kelso et al. 1990). The consequence for fish-eating wildlife is not always easy to predict, and will depend on the degree to which a species can adapt to a change in prey types. Eriksson (1984, 1986) found that some degree of acidification may be beneficial to fish-eaters, if it reduces predation on young by large fish such as pike, and by increasing water clarity so that diving birds can see fish at a greater depth. These benefits would not be as important to birds such as osprey, kingfishers or terns that take prey from surface waters and raise young elsewhere.

The situation is more complex for species of insectivorous birds that obtain prey from the aquatic environment. The Eurasian dipper is an exception in that it specializes on acid-sensitive river benthos including mayflies and caddisflies (Ormerod 1985). The breeding distribution of this species is closely related to stream pH, and numbers declined strongly on a stream that exhibited a pH drop of 1.7 over two decades (Ormerod and Tyler 1987). Other birds, including waterfowl and riparian species, appear to adapt to the lack of acid-sensitive invertebrates in acidic wetlands by modifying their diet (e.g., McNicol et al. 1987a, McAuley and Longcore 1988a, Blancher and McNicol 1991). Nevertheless, these species too may suffer reduced reproductive output and/or reduced growth of young near acidic waterbodies (Glooschenko et al. 1986, Blancher and McNicol 1988, McAuley and Longcore 1988b).

For waterfowl that feed on insects living in the water column, competition from fish is a major factor influencing food abundance (Eriksson 1984, McNicol et al. 1987a). The lack of fish in acidic lakes is therefore a benefit to some insectivorous waterfowl, and surveys have indicated that common goldeneyes (*Bucephala clangula*) and some other ducks tend to be found on lakes without fish when they have a choice (Eriksson 1984, Pehrsson 1984, McNicol et al. 1987b). The most stressful situation for these species may occur at pHs just high enough for acid-tolerant fish to survive, but where acid-sensitive invertebrates are eliminated (McNicol et al. 1987a).

This hypothesis was tested by placing black duck (*Anas rubripes*) ducklings on experimental ponds or lakes differing in pH and/or fish content (DesGranges and Rodrigue 1986, Hunter et al. 1986, Haramis and Chu 1987, Rattner et al. 1987). As predicted, the absence of fish led to increased duckling growth and foraging efficiency, while decreased pH independent of fish status resulted in poorer duckling growth and survival (*see* DesGranges and Hunter 1987). These experimental results have been supported by field surveys of ducklings on over 200 wetlands in Ontario; broods of insectivorous species were more likely to be present when wetlands lacked fish and, independently, where pH was high (Blancher et al. 1991).

The next step will be to show the impact of acidification on wildlife populations at a regional scale. The ranges of many wildlife species show a strong overlap with areas of North America where lakes have been acidified (Clark and Fischer 1981, Longcore et al. 1987, McNicol et al. 1990). Given that acidification models predict an amelioration of lake pHs in eastern North America (e.g., RMCC 1990), we may expect to see improved conditions for these wildlife in future.

Terrestrial Environment

Amphibians

A study in Delaware County, New York, has shown that the sensitivity of amphibians to acidity is not limited to aquatic species (Wyman and Hawksley-Lescault 1987). The red-backed salamander (*Plethodon cinereus*) avoids soils with a pH much below 4.0, consistent with laboratory trials that showed chronic effects on growth occurred between pH 3 and 4. The authors found that this salamander was excluded from 27 percent of forest habitat they sampled because of low soil pH.

Birds and Mammals

Studies concerned with effects of acid rain on terrestrial wildlife have dealt primarily with the questions of habitat loss and a change in metal content or nutritional value of food. The potential for changes in food abundance has not attracted much attention, probably because much less is known about the response of terrestrial biota to acidification than is known in aquatic ecosystems. Nevertheless, a variety of terrestrial plants (Hutchinson and Scott 1988, Ruhling and Tyler 1990) and invertebrates (Hagvar and Amundsen 1981, Gärdenfors 1987) are known to be affected by acidity, or indirectly through forest decline (Neuvonen and Lindgren 1987, Gunnarsson 1990, Tousignant et al. 1990). It would be surprising, therefore, if terrestrial birds and mammals did not show responses similar to those observed in the aquatic environment, with some species decreasing because of a loss of primary prey, and others experiencing an increased food abundance.

Forest decline changes the types of habitat available to forest wildlife. DesGranges (1987) predicted that as trees died back from the crown, there would be fewer canopy-feeding birds, with replacement by shrub-feeders or species relying on dead trees. Studies in Quebec among stands of declining sugar maples (*Acer saccharum*) support these predictions (Desgranges 1987, Desgranges et al. 1987, Darveau et al. 1989). The importance of this mechanism for our forest birds will depend on the extent of future forest declines, something that is difficult to predict at present.

A recent study from the Netherlands raises concern that continued soil acidification may lead to dramatic effects on forest birds (Drent and Woldendorp 1989). Over a six-year period, they observed a sharp increase in the proportion of eggs laid with no shell, or with shells of poor quality, leading to death of embryos. The effect was most predominant in forests on poor soils. They suggested that the birds were experiencing a decreased availability of calcium in insect prey in these forests, due to acidification of the soil and resulting low levels of calcium in the foliage eaten by these insects. One can also speculate that there would be fewer snail shells or similar sources of calcium rich grit in these forests, since terrestrial molluscs are sensitive to soil acidity (Gärdenfors 1987).

The implications of increased soil acidity and decreased calcium availability in forests are not limited to breeding birds. Small mammal densities may also be influenced by soil pH and nutrient availability (Krebs et al. 1971, Hill 1972, Hansson 1990). Recent studies of forest declines indicate that leaching of soil nutrients, and increases in soil aluminum, are already a problem in parts of North America receiving high acidic deposition (Shortle and Smith 1988, Cronan et al. 1989). A continued reduction of soil nutrients is predicted (Federer et al. 1989). Given this scenario, large effects on terrestrial wildlife are possible, and require study.

Need for Further Acid Rain Research

Recent decreases in sulphate deposition have resulted in chemical recovery of some lakes (e.g., Keller and Pitblado 1986, Kelso and Jeffries 1988). Control programs in the United States and Canada are expected to further reduce emissions of sulphur dioxide over the next decade. While it is tempting to view the acid rain problem as largely solved, there are a number of important reasons for continuing concern about effects on wildlife. Acidification models predict that even with a 50 percent reduction in sulphur dioxide emissions in eastern Canada and the United States, there will continue to be a large number of anthropogenically-acidified lakes in acid-sensitive regions (RMCC 1990). Even where chemical recovery does occur, very little is yet known about the extent of biological recovery that will occur, and it is probable that the ecosystems that develop will be different from those originally present (Schindler 1988). Furthermore, emissions of nitrogen oxides may play an increasing role in acidification processes in the future, and are already responsible for damage to terrestrial plants (Schindler 1988, Schulze et al. 1989). Thus, planned cutbacks in sulphate emissions may not be enough to protect our environment from further damage. Consequently, we must continue our efforts to address the acid rain problem, and its effects on wildlife.

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Aleutian Islands Plastics, Pelagic Drift and Trawl Net Problems, and Their Solutions

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Introduction

A Review of the North Pacific High Seas Drift-net Fishery

Gill-netting, designed to ensnare and catch fish by their opercula or gill plates, has been reportedly used back to Biblical times. The activity is conducted employing either set (anchored) or drift gill nets (which are allowed to drift with the prevailing currents). In the North Pacific, there is a long history of extensive drift-net fishing, particularly by the Japanese who initiated high seas salmon (*Oncorhynchus* spp.) drift gill-netting prior to World War II (Jones et al. 1991). While the Japanese have used a large-mesh fishery in their coastal waters for approximately 100 years, the salmon fishery expanded offshore into the North Pacific in the mid-1970s. In the late 1970s, drift-net fisheries for squid (*Onycoteuthis* spp.) were implemented by Japan, the Republic of Korea (ROK) and Taiwan. Today, there are seven drift-net fisheries operating in the North Pacific alone, including Japanese traditional landbased and nontraditional mothership salmon, squid and albacore (*Thunnus alalunga*); Taiwanese squid and albacore; and Korean squid. There also are vessels which fish illegally for salmon (Jones et al. 1991).

In the 1950s, the North Pacific salmon drift-net fisheries expanded rapidly, involving over 400 catcherboats in the mothership fleet and more than 1,700 in the landbased fleet over an extensive area in the North Pacific and Bering Sea, peaking at 28,796 gill-net operations annually. In 1976, the fishery began to decline, dropping to only 3,327 operations by 1989 (Harris 1989). Concurrent with the decline of the high seas salmon fisheries, high seas squid drift-net fisheries were launched by Japan, ROK and Taiwan. They currently are the largest drift-net fisheries in the North Pacific conducting over 50,000 operations per year, and deploying up to 40 miles (65 km) of net per vessel per night (Jones et al. 1991). Albacore tuna also are pursued by using pelagic drift nets in the North Pacific, this fishing technique having expanded rapidly after the closure of the U.S. and Soviet 200-mile (322 km) zones. During 1988 and 1989, approximately 460 vessels operated in the Japanese albacore drift-net fishery, while the number of vessels was limited in 1990. Taiwan fished in 1990 with approximately 124 vessels for albacore in the North Pacific (Jones et al. 1991, Suzuki 1990).

While there has been some information on fleet size and areas fished using high-seas drift-nets, little data have, until recently, been available on the actual fisheries and their bycatch (also termed incidental take or nontarget catch). Problems caused by large-scale direct as well as indirect impacts of these fisheries on marine resources caught the U.S. public's attention in the 1980s. This type of fishing gear is highly efficient. It is called "walls of death" by many environmental critics and others because of the indiscriminate manner in which they entangle and kill marine life

(Buck 1990). In addition to the capture of nontarget fish, drift-nets entangle and kill marine mammals, seabirds, sea turtles and other living marine resources. Manville (1988a, 1988b) reported rough estimates of mortality due to incidental take in the North Pacific alone of 125,000 marine mammals and 750,000 seabirds per year. "Ghost nets"—lost or discarded nets or net fragments, especially drift gill nets—can continue to fish for years, entangling fish and wildlife in the North Pacific Ocean and elsewhere. The nets sometimes sink from the weight of dead animals, seaweed or barnacles, and continue to catch fish on the oceans' bottoms. They also may ball up, continue to float or wash ashore (Manville 1991). Although documented evidence of entanglement is often anecdotal, MacKenzie (1987) estimated at least 100,000 marine mammals are believed to die in nets, net fragments and plastic debris per year.

As part of a limited 1989 open ocean observer program, witnesses from the National Marine Fisheries Service reported that 32 Japanese drift-net vessels, in an effort to catch 3 million squid, incidentally killed 58,100 blue sharks (*Prionace glauca*), 914 dolphins (Delphinidae), 141 porpoises (*Phocaena* spp.), 52 northern fur seals (*Callorhinus ursinus*), 25 puffins (*Fratercula corniculata* and *Lunda cirrhata*), 539 albatross (*Diomedeidae* spp.), 8,536 shearwaters (*Puffinus* spp.), 17 storm petrels (*Hydrobates pelagicus*) and 22 sea turtles (Cheloniidae and Dermochelyidae; Chase 1990). These data do not include the animals which were captured but released alive, and they represent only a tiny fraction of the total fishing effort in the North Pacific. Of great concern is the amount of drift gill-net deployed each night in the North Pacific, and elsewhere. Invisible and apparently acoustically undetectable to target and nontarget fish and other wildlife, some 30,000 miles (48,270 km) of drift-net—and by some estimates up to 40,000 miles (64,360 km) of drift net—are set in the North Pacific alone each night (Earthtrust 1989). The 30,000 mile-net-amount, if laid end-to-end, would encircle the globe at the equator and back across the Pacific Ocean again. Nightly use of this massive amount of net results in several problems. Incidental take is but one of them. Large quantities of target fish are also lost from drop out from these nets before or during retrieval. Another problem involves the activities of lost or discarded nets or net fragments. The National Marine Fisheries Service (NMFS), for example, estimates that Japanese vessels lose 0.06 percent of netting used per night (Hinck 1986). At 40,000 miles, that equates to nearly 24 miles (39 km) of net lost per night. This figures does not account for net purposely or accidentally discarded.

Until recently, this fishing method has not been subjected to the same critical attention that other more accessible marine resource activities have received (Buck 1990). In the 1980s, two significant public criticisms of this gear focused considerable attention on the problem resulting in Congressional action. One concern focused on the increased public sensitivity to the harmful effects of plastics to wildlife in the marine environment, especially plastic netting entangling marine wildlife. The other concern involved the increased interception of Alaska and Pacific Northwest salmon by foreign drift-net fleets in the North Pacific. Recent reports by the Pacific Seafood Processor's Association (personal communication: 1991) indicate high levels of interception and sale in Asia of some U.S.-bound salmon which otherwise could be caught both in Canadian and U.S. commercial and sport fisheries. More recent concerns with drift-net fishing for albacore in the South Pacific have further fueled recent calls for action.

A Review of the Bering Sea and Gulf of Alaska Trawl Fishery for Pollock (Theragra chalcogramma)

Commercial fishing for walleye pollock and other groundfish species was first documented in Bristol Bay, Alaska, in 1933 when large Japanese floating factories and their smaller catcher boats fished there. By the mid-1950s, Japanese-owned factory trawlers first appeared, and by the early 1970s, foreign trawlers over 300 feet (91 m) in length with crews of over 100 were not uncommon. Their towing trawl nets with openings of 300 feet (91 m) by 225 feet (69 m) enabled catches of over 1 million pounds (454,000 kg) of fish per vessel per day (Campbell 1990a). In 1979, domestic fishermen harvested but a tiny fraction of the groundfish taken in the waters off the coast of Alaska. Ten years later, Americans hauled in nearly 2 million metric tons—estimated at $2 billion—and now more than 20,000 residents of Alaska and Washington are employed in catching and processing fish. The fishery, thus, has undergone tremendous political and socioeconomic change. Since 1933, the fishery evolved from (1) primarily a Japanese far-seas fishery, to (2) an international fishery with vessels from Japan, the Soviet Union, ROK and Taiwan, to (3) a U.S./Japanese joint venture and, finally, today to (4) a U.S. fishery. It currently is the largest single-species fishery in the world (Barlow et al. 1991).

The Magnuson Fishery Conservation and Management Act of 1976 (FCMA) has fulfilled its primary goal of "Americanizing" the U.S. fisheries through establishment of a 200-mile Exclusive Economic Zone (EEZ). The fish resources within our EEZ are almost completely harvested by the United States. The problem, however, is that most major fish stocks are either fully utilized or overexploited. In Alaska, for example, the factory trawl fleet—consisting of ≥50 vessels capable of harvesting almost the entire 2.2 million metric ton quota—now has ≥20 vessels under construction, possibly resulting in a serious overcapitalization problem (Reichman 1989, Campbell 1990a).

Following the race to develop an additional new American fishing capacity, the industry is now able to catch and process more than double the current quota (Campbell 1990a). The "race" pits the groundfish industry of Seattle-based factory trawlers against fish-processing plants on Alaskan shores and the boats that supply them. By 1989, overcapitalization was precipitating a crisis. In March 1989, factory trawlers and shore-based operators together caught 40,000 metric tons of fish in 11 days, forcing premature closure of the pollock season and the closure of fish processing plants in Kodiak. To add fuel to the fire, the currently legal practice of roe stripping—roe removal from female pollock, with whole male carcasses and females minus the roe being dumped overboard—has raised serious questions about the wastefulness of this practice and the unaccountability of what is being caught and discarded. Discard is estimated at 25–50 percent of the total catch (Campbell 1990a).

Likely because of overfishing, and possibly because of the impacts of incidental take and marine debris entanglement, there are strong indications that the Bering Sea/Aleutian Islands marine ecosystem is under stress (Loughlin and Merrick 1988; Manville 1991). Marine mammal species, including Steller's sea lions (*Eumetopias jubata*), northern fur seals and harbor seals (*Phoca vitulina*), are experiencing precipitous population declines. Furthermore, seabird species have experienced reproductive failure in certain areas. Stocks of Pacific ocean perch (*Sebastes alutus*), Atka mackeral (*Pleurogrammus monopterygius*) and king crab (*Paralithodes* spp.) have not recovered from severe depressions, and Greenland turbot (*Reinhardtius hippoglossoides*) have declined since initiation of management under the North Pacific Fisheries Management Council (NPFMC)—and continue to remain depressed (Reichman and Hartmann 1988, Campbell 1990a, 1990b). While no unequivocal cause for the decline of the Steller's sea lion has yet been identified, there are no significant declines in sea lion abundance in areas where there is no extensive trawl fishery. The current decline is occurring in areas where extensive trawl fisheries have spread, both east and west from the eastern Aleutian islands as fisheries expanded (Campbell 1990a).

Methods

To assess the kinds, amounts, sources and observable impacts of plastic debris on wildlife in the Aleutian Islands, 78 beaches were examined on 21 Aleutian Islands and six open water surveys were conducted from 12–20 July 1988, 12–18 July 1989 and 20–29 June 1990 using the U.S. Fish and Wildlife Service's (FWS) research vessel M/V *Tiglax* as a home base. More time was spent surveying beaches in the western Aleutian chain (1988 and 1990) than in the eastern chain (1989). Surveys were conducted on an opportunistic basis when the *Tiglax* was either at anchor or was able to stop long enough to deploy us, and when weather and seas were sufficiently favorable to allow beach landings in a motorized Zodiac inflatable. Beach sites to be surveyed were then randomly selected, and beaches were walked and scanned for all plastic from existing sea level to the storm high tide level/ upper wrack line (Wilber 1987, Manville 1990). Representative plastic samples were collected and all beaches were photographed. Weights of plastic, especially where large quantities were evident, were estimated during the 1989 and 1990 surveys.

Attempts were made to identify the source of plastic items by linking the origin of the gear, tackle, product or piece by identifiers which were often embossed, stamped or molded into the plastic.

Six open-water plastic surveys were conducted while the *Tiglax* was steaming between islands. Surveys were conducted from either the bridge of the vessel or the flying bridge, looking for floating or drifting plastic visible from the bow of the ship while it cruised at speeds of 8–10 knots. Surveys were conducted for approximately 30-minute intervals.

Particular attention was paid to wildlife entangled in plastic. Where entangled animals were spotted, they were photographed. Carcasses were carefully examined for external evidence of plastic or for plastic entanglement scars. Rough necropsies were conducted on dead seabirds whose crops were intact to determine if plastics had been ingested.

Northern sea lion counts were conducted either from land or at sea between approximately 1000 or 1800 hours during late June and early July. This enabled peak bull, cow and pup counts (Loughlin et al. 1986, Byrd and Nysewander 1988). When counts were made on land within rookeries, numbers of sea lions were ascertained using "spook counts" where one or two researchers drove bulls and cows into the water to facilitate counting pups still on land. When counts were made from water, three or four observers counted pinnipeds 35–100 yards (32–91 m) offshore in a Zodiac inflatable. All animals were carefully surveyed for signs of entanglement using binoculars and a telephoto 35-mm camera. When counts were made by more than one observer, replicated tallies were averaged to provide the most representative value for each site.

Results and Discussion

Aleutian Islands Studies

Beach plastic debris surveys. During 12–20 July 1988, 12–18 July 1989 and 20–29 June 1990, 78 beaches, averaging approximately 110 yards (101 m) in length on 21 Aleutian Islands were examined to assess the kinds, amounts, sources, estimated weights and observable impacts of plastic debris on wildlife there. While beaches were examined from western-most Attu Island to the eastern-most Shumagin Islands, more time was spent surveying beaches in the western Aleutian chain (Near Islands, Buldir Island, Rat Islands, Delarof Islands and the Andreanof Islands; 1988 and 1990) than in the eastern chain (Unalaska Island, Aiktak Island, Ugamak Island, Poperechnoi Island, Popof Island and the Shumagin Islands; 1989). Six open-water plastic surveys also were conducted during this same period.

On the 4.9 miles (7.9 km) of beach observed during the 78 surveys and the six open-water investigations conducted, 8,694 individual plastic items (8,681 on land, 13 in the water) were counted representing 110 different plastic types. Of the 25 types of plastics whose weights were estimated in 1989 and 1990, their cumulative total weight was 27,270 pounds (12,353 kg). Fishing-related debris was generally most prevalent, including 2,081 pieces of plastic fishnet rope (weighing 9,434 estimated pounds: 4,274 kg), 1,373 styrofoam drift-net and related fishing buoys (265 pounds: 120 kg), 667 fish net fragments or complete trawl nets (13,332 estimated pounds: 6,039 kg), and 491 hard plastic fishing buoys (3,475 pounds: 1,574 kg). Of the fishnets which were distinguishable, 426 (95 percent) were trawl nets while only 22 (5 percent) were segments of drift-nets.

On the average, 111 different plastic items were found per beach survey. One 100-yard (91 m) survey on Buldir Island yielded a high of 533 plastic items. All beaches examined, including the most protected, contained plastic; at least eight items were deposited on the cleanest. Like beaches such as the Bahamas and Bermuda, which are heavily littered with plastic delivered from a large Atlantic Ocean circulation pattern known as the central gyre (Wilber 1987), the Aleutian Islands appear to act as giant "sieves" for plastic circulated by waters from the Japanese and Bering Sea currents. Given the distant and isolated nature of these Aleutian beaches, and thus the minimal opportunity for direct human deposition of plastic debris on them, the massive amount of plastic debris found there indicates a serious potential problem for entanglement and plastic ingestion by wildlife there. Furthermore, if the amount of plastic located on these Aleutian Island beaches is indicative of that found elsewhere on Alaska's 36,000 miles (57,924 km) of shoreline, the opportunity for entanglement elsewhere in Alaska also is great—and thus a further concern. There also is a serious concern over the continued apparent overboard dumping of plastic debris, fishnet fragments and other fishing gear from ships in the North Pacific Ocean. The amount of recent debris deposition may indicate a failure in compliance by those nations signatory to Annex V of MARPOL as well as compliance with enabling U.S. legislation, the Marine Plastic Pollution Research and Control Act of 1987, which prohibits the dumping of any plastic from any vessel in U.S. waters, effective 31 December 1988.

Plastic litter was identified from Canada, France, Japan, Norway, the Peoples Republic of China, Poland, ROK, Taiwan, the U.S. and the U.S.S.R., although most of the plastic could not be specifically related to country of origin. Of the items that could be ascribed a country of origin, most prevalent were items from Japan, and those identifiable were mostly fishing related.

Few animals were found entangled but alive in plastic debris or dead and entangled in debris during the 78 beach surveys. Those alive included one bull Steller's sea lion (with a cow but no pups) and two others (one bull and one cow) reported on nearby beaches. Although exact cause of death could not be positively ascertained, those animals found dead and entangled in plastic debris included one cow Steller's sea lion, and several glaucous-winged gulls (*Larus glaucescens*), one Leach's storm petrel (*Oceanodroma leucorhoa*) and one sooty shearwater (*Puffinus griseus*).

Steller's sea lion surveys and mitigation of problems in the pollock trawl fishery. I assisted FWS personnel in counts of Steller's sea lions on rookeries and haulout areas in both the western (1988 and 1990) and the eastern (1989) Aleutian Islands. While this sea lion species ranges from Hokkaido, Japan, through the Kuril Islands, the Aleutian Islands and Central Bering Sea, to the Gulf of Alaska, southeast Alaska, and south to central California, its center of abundance and distribution is the Gulf of Alaska and the Aleutian Islands. Most large rookeries are in the Gulf of Alaska and the Aleutian Islands, with more than 50 rookeries and a number of haulout areas identified (Fox 1990). Counts, including these by the FWS, were being conducted to assist NMFS in ascertaining the status of the population.

Because of a precipitous decline in the Steller's sea lion population, it was listed as a threatened species by NMFS under the Endangered Species Act's (ESA) emergency interim basis on 5 April 1990, and on the permanent list on 4 December 1990. Its numbers on certain rookeries in Alaska have declined by 63 percent since 1985 and by 82 percent since 1960. During the 1985 breeding season, for example, 68,000 animals were counted on Alaska rookeries from the Kenai Peninsula to Kiska Island, compared to 140,000 counted in 1956–1960. A comparable 1989 study showed the number observed from Kenai to Kiska to have declined to 25,000 animals. The 1990 count was similar to the 1989 count (Fox 1990, FWS 1990). The worst sea lion decline appears to be in the eastern Aleutians where their numbers have dwindled from 50,000 to 3,000 (Associated Press 1990). While many of us in the environmental community petitioned the Steller's sea lion for emergency listing as endangered under ESA, NMFS assures us that if the decline continues at the rate during the past decade and the decline continues to spread, that reclassification will be considered.

Many observers have implicated that trawl fisheries as a major contributor to the decline of this species, in major part by depleting the sea lion's prey species—most notably the walleye pollock, 8–18 inches (21–46 cm) in length, in the southeastern Bering Sea and Gulf of Alaska (Loughlin and Merrick 1988, Campbell 1990a, 1990b). There also are reports of fishermen and others shooting adult Steller's sea lions at rookeries, haulouts and in the water near boats. The magnitude of this problem, however, is unknown (Fox 1990). Studies on toxic substances affecting the Steller's sea lion have been inconclusive. Disease and predation by sharks, killer whales (*Orcinus orca*) and brown bears (*Ursus arctos*) are potential factors affecting this species, but their impact is probably not significant. An estimated Native subsistence take of less than 100 sea lions per year is not significant.

The incidental take of sea lions in commercial fishing operations in the Gulf of Alaska and Bering Sea is significant, but does not alone account for the precipitous decline. Between 1973 and 1988, for example, U.S. observers on foreign and joint venture vessels operating in this area reported 3,661 marine mammals taken, 90 percent of which were Steller's sea lions. Based on observed takes and an extrapolation to unobserved fishing, the total Steller's bycatch from 1973–1988 was estimated at 14,000 (Fox 1990).

While entanglement in fishing debris has been considered a possible contributing factor affecting sea lions in the eastern (Loughlin et al. 1986, Byrd and Nysewander 1988) and western Aleutian Islands (Manville 1991), the tiny fraction of the total population observed entangled does not point to this as a significant problem. However, since pups and juvenile sea lions, like their northern fur seal counterparts, are curious, inquisitive and playful (King 1983), they may suffer much higher mortality due to entanglement in plastic fishing debris than observed. Since entanglement is suspected by this author to be a contributing factor in the Steller's decline, more detailed study and analysis are needed.

The threatened listing of the Steller's sea lion resulted in immediate implementation of several protective measures. Observers will continue to be required onboard all foreign processors and domestic groundfish vessels ≥125 feet (38 m) in length during all operations within our EEZ of the Bering Sea and Gulf of Alaska. Groundfish vessels 60–124 feet (18–38 m) in length will continue to carry observers during 30 percent of their operations each quarter. NMFS has prohibited the discharge of any firearm within 100 yards (91 m) of a Steller's sea lion. NMFS established a 3-nautical mile (5.5 km) buffer zone for all vessels around the principal sea lion rookeries in the Gulf of Alaska and the Aleutian Islands, a 0.5-mile (0.8 km) buffer approach zone on land and a 1.5-mile (2.4 km) buffer approach zone on land for Marmot Island. NMFS has prohibited the incidental kill of more than 675 Steller's sea lions, resulting in area closures and fish allocations when this quota is exceeded (Fox 1990). Recommendations for critical sea lion habitat will appear in the final recovery plan and final rulemaking tentatively to be released by mid-1991.

While these protective measures are intended to help, they appear to be difficult to enforce and cosmetic, failing to get at what may appear to be the apparent root of the problem. Because factory trawlers and Steller's sea lions compete for the same pollock, the groundfish industry may be responsible in major part for the seal lion decline. NPFMC, as established by the FCMA, is one of eight councils which regulates regional fisheries. Seven of its 11 members, however, are from the seafood industry. It is considering a proposed moratorium on entry of new vessels into the fishery. At present, fishermen can take a total of 2 million metric tons of various groundfish. The Alaska Factory Trawling Association wants the limit raised to 2.8 million metric tons. At the very least, if a moratorium is not imposed, the Steller's sea lion and the fishery may both collapse.

To deal with the problem will require some tough action. This may require (1) limiting trawling to daylight hours to reduce incidental take, (2) prohibiting fishing for pollock when they are carrying roe, (3) reducing the overall quota on groundfish facilitating sea lion recovery, (4) reducing the level of take of one-to-three year pollock, (5) further reducing the incidental kill of sea lions below the current annual 675 level, (6) further increasing fishery buffer zones around sea lion rookeries and haulout areas, (7) more closely regulating subsistence hunting of sea lions, (8) eliminating the dumping of net debris into the oceans, (9) reducing or eliminating fisheries in areas that have the greatest impact on sea lions, (10) educating fishermen to the folly of continuing to shoot sea lions, and (11) possibly imposing a user fee on trawl fishermen (the money to be used for enforcement and implementation). Since there is a lack of information on bycatch, especially with the Alaska pollock trawl fishery, part of the solution may also be (12) a required public release of tonnages and bycatch information by time and area from each fishery (Reichman 1989). And (13), the use of gill-nets around sea lion rookeries should also be prohibited (Campbell 1990a, 1990b, Fox 1990).

Solutions to Pelagic Drift-net Problems

The massive quantities of nondegradable drift gill-nets have the potential of wreaking havoc in the North Pacific ecosystem to such an extent that, some believe, if they continue unchecked, they will and are exhausting a natural resource that once was considered inexhaustible (Nobbe 1990). In an attempt to begin to deal with the drift-net problem, the 100th U.S. Congress passed the Driftnet Impact Monitoring, Assessment, and Control Act of 1987. The Act directed negotiations with Japan, ROK and Taiwan; provided possible certification under the Pelly Amendment to the Fishermen's Protective Act if adequate agreements were not reached; required evaluations and reports; and authorized appropriations (Buck 1990). While the Act was a watered-down version of what many of us in the environmental community wanted, it did begin to set a standard for dealing with this high-seas problem.

Precipitated by overfishing by Japan and Taiwan for albacore with drift nets in the South Pacific, 20 South Pacific nations negotiated an international treaty called the Wellington Convention in November 1989. The protocol calls for an end to drift-netting within the EEZ's of the signatory nations. The nations, however, have no jurisdiction over drift-netting in international waters.

Under a U.S. initiative, the United Nations General Assembly (UNGA) passed Resolution No. 44/225 on 22 December 1989, calling for a global moratorium on large-scale ($\geq$ 1.5 statute miles [2.4 km]), high-seas/pelagic drift nets by 30 June 1992. The Resolution also calls for a moratorium on high-seas drift-netting in the South Pacific by 1 July of this year. While the effort is nonbinding, and does not apply to either ROK or Taiwan, neither of which is a member of the U.N., it is highly symbolic of the growing international concern about this burgeoning problem. This, in fact, is the first global discussion and response to this problem outside of regional groups or in bilateral negotiations (Daves and Reichman 1990).

In part as the U.S. response to the UNGA Resolution, Congress passed and President Bush signed into law amendments to the FCMA Reauthorization on 28 November 1990. Under Title IX of the Act, the law mandates a ban on the importation into the U.S. of any fish or fish product harvested in high-seas drift-nets in the South Pacific beginning July 1991, and any drift-net caught fish from any ocean of the world beginning July 1992. The Act also instructs the President to seek a treaty banning large-scale drift-nets ($\geq$ 1.5 statute miles in length). Importation into the U.S. of all tuna and tuna products captured in drift-nets will also be banned globally, effective July 1991.

Since Japan won approval of a provision in the 1989 UNGA Resolution permitting a freeze to be lifted if the international community agrees on "effective conservation and management measures" that prevent unacceptable impacts of drift-nets (Manville 1990), it is attempting to develop "sound management practices" which will exempt it from the 1992 UNGA moratorium. These include modifications to nets whose tops are several yards below the sea surface (Yatsu 1990), net which phosphoresce in the dark and even vessels with incinerators used to burn drift-net before it is discarded (Sproul 1990).

The consensus among most of use in the environmental/nongovernmental organization (NGO) community is that large-scale, pelagic drift-nets must be banned worldwide. Congress and the Administration seem to agree. To this end, we presently are working with the U.S. Department of State, as well as with NMFS, and a number of foreign countries to reach this end. While we likely will ultimately be successful in this effort, drift-netting will continue to be used, but in a much smaller way, as a fishing alternative around the world. The FCMA calls for more research into degradable options for drift-nets, including both historic (e.g., cotton, linen and hemp) and new biodegradable plastic alternatives (e.g., chitosan-derived plastic made from chitin from shellfish waste; Nicol 1991).

To stop the now illegal dumping and disposal of plastic fishing gear and line within our EEZ, better enforcement of the Marine Plastic Pollution Research and Control Act is imperative. For those countries signatory to Annex V of the MARPOL Protocol, better education and enforcement efforts are necessary to teach fishermen not to discard drift- and trawl nets, and other plastic gear overboard into the oceans of the world. Nations not yet signatory of Annex V should be encouraged to ratify and subscribe to it.

Some argue that more data are needed on drift-net impacts worldwide, including those on great whales, other marine mammals, seabirds, sea turtles and other living marine resources. Others argue that large-scale drift-nets can be made safe, selective and controllable. As the boat captain of a drift-net vessel recently exclaimed, "We don't kill nearly as many dolphins as we used to." Responded an environmentalist, "That's probably because there aren't that many left to kill." (Nobbe 1990). The time, therefore, to save our marine ecosystem from the scourge of large-scale drift-nets is now. We simply can not wait any longer.

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Impact of Human Population on Wildlife Resources in Nigeria[1]

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Introduction

Nigeria is located in western Africa, north of the equator. It is bordered by Cameroun and Chad to the east, Niger to the north, and Benin to the west, with a coastline 780 km long. With a total area of 923,768 sq. km, Nigeria is an African country of average size but it is the most populous, with an estimated 115 million people and an overall population density of 110 people per sq. km. Higher densities are found in the south of the country around the cities of Lagos and Ibadan, and in Kano area in the north. Nigeria's population growth rate of 3.4 percent is the sixth highest in Africa. One out of five Africans is a Nigerian.

There are 20 states in Nigeria and a Federal Capital Territory. Wildlife management responsibilities are shared between the federal and state administrations in a fashion similar to the Canadian situation, the states having the main administrative responsibilities regarding wildlife management in their territory, and the federal administration dealing with broader national or international concerns such as the administration of national parks, the control of trade and the conservation of endangered species.

Nigeria has been blessed with a rich and unique array of ecosystems and a great variety of wildlife. Broad climatic variations, ranging from a wet, humid, sultry climate in the south to a hot, dry, semi-desert climate in the north, with a wide range of intermediate climates in between (Happold 1987) have resulted in a north south gradation of habitats, from coastal mangrove and rain forests in the south where precipitations range from 1,600–4,000 mm, to deserts in the north, with various types of savanna in between. The vegetation zones tend to run in broad bands across the country, from east to west (Happold 1987). This great diversity of habitats supports more than 1,340 animal species, among which are 274 mammals and 831 birds, and 4,600 species of plants. Nigeria ranks as one of the richest country of Africa in term of diversity of wildlife. At least two mammal species, two bird species and 205 plants species are endemics.

The growing human populations and the way these people earn their living exert an enormous pressure on natural resources. In Africa, harvested species make a considerable contribution to human welfare in the form of food for rural people, and especially to the poorest villagers living in the most remote areas. In Nigeria, 68 percent of the labour force in 1980 was engaged in agriculture; a significant portion of farmers income originates from bushmeat exploitation (Holland et al. 1989). Ajayi (1971 [cited by Sale 1981]) reported that game constitutes about 20 percent of the mean annual consumption of animal protein by people in rural areas. In 1963 at the

[1]Based on observations made in Nigeria while developing a wildlife survey and monitoring program for the IUCN and the government of Nigeria

last official population census, 26,700 people had indicated hunting as their main income. This estimate can possibly be multiplied by a factor of two now that the overall country population has doubled. A variable proportion of this harvest is consumed directly rather than being sold in the market place, but the value is nonetheless significant and economic values can be assigned for various types of use.

Value of Biological Resources in Nigeria

Charter (1970 [cited in Adeola 1987]) estimated the value of bushmeat consumed annually in southern Nigeria at 20 million naira and Afolayan (1980) for the whole of Nigeria at 30 million naira, and the total value of naturally-produced protein food at 100 million naira (12.5 million $US). An estimate of the bushmeat trade for the whole of Nigeria by Martin (1983) gives a value of 150–200 million naira (cited by Adeola 1987).

In the 34 villages found in the vicinity of the Cross River National park in the rain forest belt, the revenue obtained from gathering, hunting and trapping amounted to more than 31 million naira in 1989, (7.8 million naira from gathering, 16.1 million naira from hunting, and 7.0 million naira from trapping) an average per capita income of 826 naira (Holland et al. 1989). According to Infield (1988), in a nearby area in the vicinity of Korup National Park in Cameroon, approximately 38 percent of the total villages income is derived from hunting, indicating that hunting was the single-most important economic activity in the villages studied.

The present wildlife exploitation rate is stimulated by high prices and economic hardship. The demand for wildlife is likely to exceed the supply, according to Falobi (1988) who has shown that the actual deficit of 269,000 tons will have tripled in year 2000, a significant loss for the hunters/farmers and a serious threat to the country's food self-sustenancy. However, the high price that bushmeat commands diverts this source of protein in favor of the more wealthy segment of the population. Conserving the wildlife resource and devising approaches to exploiting it on a sustainable basis are important economic preoccupations in such situations.

Impact of Human Activity on Conservation of Wildlife and Habitats

Conservation of the country's wildlife resources is precarious. Due to a number of factors, there has been, over the years, drastic reductions of wildlife populations levels and distribution.

Even though a substantial number of game reserves have been established in the past to counter the trend, and the National Parks will soon total five with the recent proposal to add four new parks, these conservation areas have been plagued with recurrent management problems that have diminished their value. According to Anadu and Green (in preparation), at present, the level of protection of wildlife in Nigeria's conservation areas range from poor to non-existent. For example, although MacKenzie (1978) mentions that 539 hunters were arrested in a ten-year period at Kanji Lake National Park, the author also reports that in a period of two years (1976–78), 321 animals were estimated being illegally taken by hunters at the same park. Afolayan (1980) estimated a standing biomass of 349 kg/sq. km in Yankari Game Reserve, Nigeria, compared to a range of 1,098 to 4,032 kg/sq.km for other protected areas in neighbouring countries; Cameroon; Benin; and Central African Republic. He concludes that this is likely due to illegal hunting.

The case of Kanji Lake National Park may be typical: conflicts between wildlife conservation authorities and nomadic herdsmen; large scale enchroachment by agriculture; illegal hunting; and insufficient finance, personnel and equipment are prevalent. The country's other savanna game reserves receive even less conservation attention.

Many of the savanna habitats are also suffering from overgrazing by liverstock: 1 million Fulani roam the country and utilize any available habitat to feed their estimated 48 million cattle, goats and sheeps, the equivalent of 230 grazing animals per sq km of grassland.

Nigeria has suffered from excessive clearance of woodland: the broad belt of rain forest that covered the southern part of the country can now only be found in scattered patches, with a larger expanse near the Cameroun border to the east. 90 percent of the rain forest areas has been clear-cut and deeply transformed by agriculture and plantations. The extent of the rainforest zone in Nigeria, approximately 5,000 ha or 5.6 percent of the country area, is only a small fraction of its extent in 1900, and many predictions suggest that, by the year 2000, outside of protected areas there is unlikely to be much rainforest left (Happold 1987). There are more species of mammals in the rainforest zone than in any other vegetation zone in Nigeria. One hundred and twenty-nine species have been recorded, 51 percent which are rodents and bats.

The impact of habitat loss and excessive exploitation has had serious repercussions on wildlife.

- More than 51 species or groups of species are presently considered endangered, 30 of which are globally threatened (Table 1).
- Nine of 24 species of primates are of conservation concern.
- The wide range of natural habitats in Nigeria once supported a diverse antelope fauna comprising 25 species. All of these species were formerly widespread within the savanna. However, the larger species are now mainly or entirely confined to conservation areas. (Happold 1987)
- Manatees and hippopotamus status need to be investigated.
- Elephants number approximately 3,000 in scattered herds.
- Wild dogs are reduced to near extinction; leopards are the object of a high hunting pressure and their situation is more problematic due to the disappearance of the big game species in their range.
- Birds constitute one of the outstanding particularities of Nigeria in term of biodiversity and wildlife. As indicated above, more than 850 species of birds have been observed in Nigeria, 700 or so being breeding species. The remaining 150 are palearctic migrants (Elgood 1982, Ash 1987, Ash and Sharland 1987, Collar and Stuart 1988, Wilkinson and Beecroft 1988). This unique situation should encourage the country to make particular efforts to continue the development of a good data base on birds to ensure their conservation.

  The continuing transformation of the habitat has affected birds distribution and density. But the wetland transformations can be more threatening. The northern part of Nigeria offers outstanding wintering habitat for numerous palearctic bird species, as well as important, but recently declining, African spe-

Table 1. Endangered, threatened and other animals of conservation concern in Nigeria (IUCN categories- Ex: extinct; E: endangered; T: threatened; V: vulnerable; I: indeterminate; R: rare; K: insufficiently known).

Species	Category	Reference[b]
Reptiles and amphibians		
Boidae		
Python regius Royal python	E	7
Python sebae Rock python	E	7
Varanidae		
Varanus niliticus Nile monitor lizard	E	7,8(I)
Varanus examthematicus Short-tailed monitor lizard	E	7,8(I)
Crocodylidae		
Crocodylus cataphractus African slender-snouted crocodile	I	1,7,(I)
Crocodylus niloticus Nile crocodile	V	1,7,8(I)
Osteolaemus tetraspis West African dwarf crocodile	I	1,8(I)
Arthroleptidae		
Cardioglossa schioetzi	E	5
Cardioglassa melanogaster	I	8
Leptodactylon bicolor	I	8
Chelonidae		
Eretmochelys imbricata Hawsbill turtle	?	8
Lepidochelys olivacaea Olive Ridley turtle	?	8
Birds		
Struthionidae		
Struthio camelus Ostrich	V	7
Pelecanidae	V	7
Ardeidae	V	7
Ardeinae	V	7
Scopidae		
Scopus umbretta Hammerkop	V	7
Ciconiidae	V	7
Plataleinae		
Platalea alba Spoonbill	V	7
Aegypinae	V	7
Accipitrinae[a]	E	7
Sagittariidae		
Sagittarius serpentarius Secretary bird	V	7
Falconidae[a]	E	7
Gruidae	V	7
Otitidae	V	7

Table 1. (Continued)

Species	Category	Reference[b]
Laridae		
Sterna balaenarum Damara tern	K	8
Psittacidae		
Agapornis pullaria Red-headed lovebird	E	7
Poicephalus robustus Brown-necked parrot	E	7
Poicephalus senegalus Senegal parrot	E	7
Psittacula krameri Long-tailed parakeet	E	7
Psittacus erithacus Grey parrot	V	4,7(E)
Apodidae		
Apus barbatus (sladeniae) Fernando Po swift	K	5,8
Bucerotidae		
Bucorvus abyssinicus Abyssinian ground hornbill	V	7
Laniidae		
Malaconotus gladiator Green-breasted bush-shrike	R	5,8
Timaliinae		
Loptilus gilberti Mountain babbler	R	5
Muscicapinae		
Picathartes oreas Grey-necked picathartes	R	1,8
Prinia fluviatilia River prinia	K	1
Estrildidae		
Estrilda poliopareia Anambra waxbill	K	1,8
Ploceinae		
Ploceus bannermanii Bannerman's weaver	V	1,5,8
Malimbus Ibadanensis Ibadan malimbe	E	1,8
Mammals		
Tenrecidae		
Potamogale velox Giant otter-shrew	E	7
Lorisidae		
Arctocebus calabarensis Angwantibo	K	1,2,7(E),8
Cercopithecidae		
Cercocebus torquatus Red-capped mangabey	V	1,2,7(E)
Cercopithecus diana Diana monkey	V	1
Cercopithecus erythrogaster White-throated guenon	E	1,2,8
Cercopithecus erythrotis Red-eared guenon	E	1,2,8(?)
Cercopithecus preussi Preuss's guenon	E	1,8(?)
Procolobus badius Western red colobus	V	1,8(Ex)
Procolobus verus Olive colobus		1,2(R)
	V	7(E)8(?)
Mandrillus leucophaeus Drill		1,2,7
	E	8(Ex)
Pongidae		
Gorilla gorilla Western lowland gorilla	V	1,2,7(E) 8
Pan troglodytes Chimpanzee	V	1,2,7(E) 8

Table 1. (Continued)

Species	Category	Reference[b]
Manidae		
Manis tetradactyla Long-tailed pangolin	E	7
Manis tricuspis Tree pangolin	E	7
Manis gigantea Giant pangolin	E	7
Histricydae		
Atherurus africanus Bush-tailed porcupine	E	7
Canidae		
Lycaon pictus Hunting dog	E	7,8(I)
Mustelidae		
Aonyx capensis Cape Clawless otter	E	7,8(I)
Lutra maculicollis Spotted-necked otter	E	7,8(I)
Hyaenidae		
Crocuta crocuta Spotted hyaena	E	7,8(I)
Hyaena hyaena Striped hyaena	E	7,8(I)
Felidae		
Felis caracal Caracal	E	7,8(I)
Felis libica African wild cat	E	7,8(I)
Felis serval Serval	E	7,8(I)
Acinonyx jubatus Cheetah	V	1,7(E) 8(I)
Panthera leo Lion	E	7,8(I)
Panthera pardus Leopard	T	1,7(E) 8(I)
Trichedidae		
Trichechus senegalensis Manatee	E	1,7,8(I)
Oryteropodidae		
Orycteropus afer Aardvark	E	7,8(I)
Elephantidae		
Loxodonta africana African elephant	V	1,7,8(I)
Suidae		
Hylochoerus meinertzhageni Giant forest-hog	E	7,8(I)
Hippopotamidae		
Choeropsis liberiensis Pigmy hippopotamus	V	1,7,8(I)
Tragulidae		
Hyemoschus aquaticus Water chevrotain	E	7,8(I)
Giraffidae		
Giraffa camelopardalis Giraffe	E	7,8(I)
Bovidae		
Taurotragus derbianus gigas Giant eland	E	1,3,7,8(I)
Tragelaphus seristus Bushbuck	I	8
Tragelaphus spekii Sitatunga	E	3,7,8
Cephalophus maxwellii Maxwell's duiker	V	3,8
Cephalophus monticola Blue duiker	V	3,8(I)
Cephalophus rufilatus Red-flanked duiker	V	3,8(R)

Table 1. (Continued)

Species	Category	Reference[b]
Cephalophus dorsalis Bay duiker	E	3,8
Cephalophus ogilbyi Ogilby's duiker	E	3,8(I)
Cephalophus niger Black duiker	E	3,8(V)
Cephalophus sylvicultor Yellow-backed duiker	E	3,7,8
Sylvicapra grimmia Common duiker	R	8
Redunca redunca Bohor reedbuck	E	3,8(V)
Redunca fulvorufula Mountain reedbuck	E	3,8
Kobus ellipsiprymnus defassa Waterbuck	V	3,8
Kobus kob kob Buffon's kob	V	3,8
Hippotragus equinus Roan antelope	E	3,8(R)
Oryx dammah Scimitar-horned oryx	Ex.	3
Alcelaphus buselaphus Western hartebeest	V	3,8(R)
Damaliscus lunatus Korrigum	E	3,8
Gazella dorcas Dorcas gazelle	E	3,7,8(Ex?)
Gazella rififrons Red-fronted gazelle	E	3,8(V)
Neotragus batesi Bate's dwarf antelope	E	8
Gazella Dama Dama gazelle	E	3,7,8(Ex?)
Neotragus aurebi Oribi	E	3,8(I)
Oreotragus oreotragus Klipspringer	E	3,7,8

[a]All Accipitrinae (eagles, harriers, sparrowhawks, buzzards, kites) and all Falconidae are listed as Endangered by reference 7.

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cies. The Nguru-Hadejia wetlands, as well as the Lake Tchad areas constitute the core of this wintering habitat. These areas are the continuation in Nigeria of a broad belt of wetlands stretching from Senegal to Chad, refered to as the Senegal, the Niger and the Chad basins. Lake Chad is also an important breeding area for African species such as herons, cormorants, ibises and smaller aquatic birds (Elgood 1982).

Based on many years of winter counts and observations Roux and Jarry (1984, 1986, 1987) have reported up to 1.5 million waterbirds using that broad area in winter, half of which can be found in Nigeria. Lake Chad stands out in that context as an area with an enormous potential for wintering birds, particularly in the present drought situation where birds seem to be concentrating along its shores.

Nigeria is presently taking measures to overcome a difficult economic situation created by the country's economy's strong reliance on oil and the fluctuating oil prices. The 10-year boom in oil prices of the seventies deeply changed Nigeria's way of life. From a situation of self-sufficiency in food production, it became a massive importer of cereals such as wheat and rice, milk, fish, sugar and even oil. These goods represented in 1980 more than one-fifth of the country importations. When the oil prices started falling in 1982, strong controls were imposed on importations of food, and to meet the newly created food needs it became necessary to start a domestic production of some cereals which necessitated setting up irrigation projects. This diversion of much needed water in the northern portion of the country, coupled with the large scale desertification of the Sahel, is having an impact on these valuable wintering areas and on Lake Chad.

The conservation problems presently facing the country can, thus, be summarized as follow

- A high population growth rate and an important competition for space between different groups of users and types of use—farmers, cattle breeders and conservation areas.
- Excessive harvest of wildlife by the subsistance and the commercial hunters.
- Irreversible transformation of the rain forest belt and non-sustainable exploitation of the remaining patches, causing continuing and important loss of unique wildlife habitat. As indicated above, Nigeria has now lost more than 90 percent of its primary moist lowland forest, and due to a number of factors, among which human activity certainly ranks high, the northern boundary of that important ecological area has retreated more than 100 km in the last 50–80 years, replaced by derived savanna (Anadu and Green in preparation).
- Indiscriminate fires (Afolayan [1978] offered an interesting discussion on this question) and industrial development particularly in the mangrove, affect habitat.
- Competition for water resource in the Chad basin in the north of the country, threatening important wetlands used by migratory birds as wintering area and a vital subsistence farming economy.
- Lack of sufficient funding and personnel for the government conservation agencies at the federal and states levels.
- Insufficient public awareness for the conservation problems.

Management Recommendations

To alleviate some of these problems, the following management recommendations are offered:

1. Determine the status of species. The status of major wildlife species need to be determined by a thorough survey and the populations trends monitored over a number of years.
2. Review and implement the existing laws. Although a total ban of hunting is certainly necessary in many cases to protect threatened species, it may be preferable to consider establishing seasons, hunting zones or quotas through regulations, instead of a total ban that is not enforced as is now the case. A better adapted legislation will be more easily accepted, respected by the population and enforced. Conservation officer positions also need to be established through-

out the country to implement Decree #11—a federal legislation aiming at conserving threatened species, incorporated into some of the states legislation. Presently, it is only at airports and in some reserves parks that enforcement takes place. There is no wildlife law enforcement in the country outside of protected areas even for species that urgently need protection.

Better equipment, better training, higher classification levels, and better working conditions and incentives for existing enforcement positions in parks and reserves are also needed. The wardens' positions are presently at a level too low to attract interested candidates with sufficient education.

3. Protect essential habitats. Presently, only 3 percent of the total area is under some form of protection for wildlife conservation, and due to relaxed enforcement efforts, these conservation areas are not sufficiently protected. It is generally considered that 10 percent is an acceptable minimum that should be aimed at. The following measures are proposed.
   - Habitat protection legislation should be developed. A list of habitats essential for the conservation of endangered species needs to be established and specific protection afforded to the identified sites. The protection of wetlands against alternative use of water, for example irrigation projects in the Kano area, need to be insured in a country that is suffering from increased desertification.
   - Outstanding areas, such as existing parks and reserves, should be protected and the sites identified under an habitat protection legislation against detrimental factors, such as grazing, uncontrolled wood cutting and fires. The problem of widespread grazing by the nomadic Fulani cattle needs to be addressed as a national issue.
   - To obtain the collaboration of the population, the creation and existence of parks and reserves should be publicized and their limits posted.
   - Protection of additional areas for threatened species by creating additional national parks in the rainforest, west of the Niger river, and in the mangroves, is recommended. Little is known about the wildlife composition of mangroves. The proposed site would not only protect a unique representative area of the Nigerian landscape, but would also protect animals such as the Manatee and the Pigmy Hippopotamus, which are known to occur in the Niger delta.
4. Basic research on threatened populations or animals needs to be amplified in universities and supported financially. This is particularly necessary for amphibians, bats and monkeys, but also for small carnivorous animals.
5. Development of a bushmeat domestic production program. Many reports dealing with conservation in Nigeria and elsewhere in Africa recommend developing programs of commercial production of bush meat for domestic use, thereby reducing the harvest of wild animals. This question has been well-covered by Dore (1981). Sale (1981) cites Asibey and Ajayi as having done considerable research on the suitability of the cane rat (grass-cutter) and giant rat, respectively, as candidates for domestication. The giant african land snail has also been considered (Sale 1981) due to its high protein content (74 percent) and palatability.
6. Circulation of scientific literature and reports. Very little opportunity of access to scientific literature or to scientific reports on wildlife are offered to professional

government employees engaged in active field work. Systematic distribution of recent documentation should be organized to meet this very basic need.

7. Interaction with the public; Make people benefit. People, particularly those living in rural communities are not aware of the serious conservation problems that the country is facing. When efforts are made to involve people in the decision-making process regarding management of wildlife in rural communities, the results are extremely encouraging, as it has been experienced in Kano Sate with the creation of the Community Relation Committees and the Local Government Conservation Committees. An education program should not be aimed solely at informing people, but should also involve them in the management process as suggested by McNeely (1988). Of utmost importance is the necessity of making people directly enjoy economic benefits originating from conservation.
8. Publicity (national and international) on government accomplishments. It would be in the country's interest to publicize at the international the conservation measures taken by the government. In this age of ''eco-tourism,'' this publicity would attract international interest in the country and the increased potential it offers to wildlife viewers. Among Nigeria's accomplishments in conservation.
    - Nigeria is a party to CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora), the African Convention for the Conservation of Nature and Natural Resources (1968), the World Heritage Convention (1972), and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention 1979).
    - A national conservation strategy has been developed and is in the process of being officially supported by the government (Anonymous 1986).
    - 12 game reserves and one national park are officially gazetted. Four additional parks have been recently designated.
    - A National Conservation Council, under the chairmanship of the President of the country, is in existence.
    - Wildlife chairs have been developed in many universities and well-trained professionals are holding leading positions in the government administration.
    - International conservation agencies such as ICBP (International Council for Bird Preservation), RSBP (Royal Society for the Protection of Birds), IUCN, WWF (World Wide Fund for Nature) in collaboration with the Nigerian Conservation Foundation have supported a number of conservation projects in the country, as well as seminars and workshops.

Conclusions

The contribution of wild species and ecosystems to the economies of developing countries is usually far greater than it is for industrialized countries. In comparing wood and non-wood forest resources, Myers (1988), in McNeeley (1988), concludes that a tropical forest tract of 500 km^2 could, with effective management, ''produce a self-renewing crop of wildlife with a potential value of at least $10 million per year, or slightly more than $200 per hectare. These revenues contrast with the return from commercial logging in the area of only a little over $150 per hectare. Moreover, with present timber-harvesting practices, commercial logging tends to be an ecologically disruptive procedure, whereas wildlife harvesting can leave forest ecosystems virtually undisturbed.''

The returns from wildlife will be far less in drier habitats, though often exceeding alternative uses. In Zimbabwe's Zambesi Valley, for example, Cumming (1985), cited by McNeeley, estimates that potential gross returns from wildlife utilizations amount to $12 per hectare. ''These returns'' he states, ''are as good if not better than returns from the best-run commercial beef ranches in the country and the profit margins are probably higher.''

In Kenya, tourism is the leading foreign exchange earner, and much of the tourism is based on Kenya's system of protected areas. For example, each lion in Amboseli National Park has been estimated to be worth $27,000 per year in visitor attraction, and each elephant herd is worth $610,000 per year; the park yields net earnings, mostly from tourism, of about $40 per hectare per year, some 50 times the net profit under the most optimistic agricultural projection (McNeeley 1988).

Due to declining big game populations and the lack of a proper infrastructure, Nigeria has not yet been able to develop a similar eco-tourism attraction. With proper conservation measures, such an objective could eventually be attained. But the very high value of wildlife for subsistence (not to mention cultural and medicinal) purposes is in itself a very strong argument for its conservation. The actual replacement value in terms of human food is very important and, with the expanding population, will continue to increase. A choice in development scheme needs to be made that will not threaten this reliance of people on wildlife, an argument for its conservation and an economic benefit for the country.

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Joining Efforts for the Preservation of Biodiversity

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Introduction

Our planet is poised on the edge of an unprecedented biological disaster (Wilson 1989). According to Norman Myers (1985), over 1 million species of animals and plants may become extinct in the next two decades alone. Myers based this figure on the conservative estimate that 5 million species of animals and plants live on Earth and relating deforestation and habitat destruction to species diversity. We know now from Terry Erwin's (1988) estimates that up to 30 million species may inhabit our world. If one-fifth of the world's biodiversity is destroyed, up to 5 million species may be lost in less than 20 years. This mass extinction is primarily due to human activities: modification and destruction of natural habitats; overexploitation; introduction of exotic species; pollution of ecosystems (Ehrlich and Ehrlich 1981); and climatic changes associated with global warming (Peters 1990)

If these dire predictions come true, they will undoubtedly have many unforeseeable consequences for natural ecosystems and for many aspects of our culture and economy. The value of conserving biodiversity has been discussed by many in search of arguments to protect our living planet and conserve the indispensable life sustaining ecosystems. Among others, Myers (1978, 1979) and Oldfield (1984) have eloquently demonstrated the close link between economy and environment in showing that plants and animals are at the origin of countless commercial products: medicines, oils, resins, food, drinks, building material, colourings, natural fibres, biological fertilizers or insecticides. The list of such products grows longer each day. The recreational value of wildlife is enhanced by the fact that in Canada, some 91.3 percent of the population participated in an activity related more or less directly to wildlife in 1987 and that such activities resulted in expenditures totalling some $5.1 billion (Environment Canada 1989). Living species also have immense scientific value. Wildlife studies help us understand our own place in the universe, as well as the inner workings of our minds and our bodies. A certain number of species, such as emblematic plants and animals, have played and continue to play a significant role in the cultural life of peoples. The intrinsic uniqueness and beauty of each living thing should also prompt us to conserve all forms of life (Callicott 1986). In that vein, Edward Wilson (1984) even suggested that conserving biodiversity was the natural outcome of humanity, the expression of biophilia, the affinity of human beings for all living things.

But the destruction of living species may hinder the functioning of ecosystems, thereby putting to jeopardy what Paul Ehrlich (1985:160) calls a "whole series of little recognized but absolutely essential services without which civilization cannot exist—indeed, without which *Homo sapiens* cannot exist." Indeed, biologically diverse ecosystems perform vital ecological services such as decomposition of wastes, purification of air and water, and cycling of nutrients (Salwasser 1990).

The preservation of biodiversity seems to be an overwhelming challenge, and success will only be possible through the concerted efforts of numerous individuals and organizations. In 1980, this task was defined as one of the three major goals of the World Conservation Strategy (IUCN-UNEP-WWF 1980). Ten years later, a growing number of countries are calling for an international convention to conserve biological diversity (Westman 1990). In North America, the responsibility for conservation ultimately lies with government agencies. However, non-governmental organizations (NGOs) are playing an ever-expanding and sophisticated supporting role.

From Status Reports to Recovery Plans

In Canada, the federal government's role in the conservation of biodiversity officially started in 1978, with the creation of the Committee on the Status of Endangered Wildlife in Canada or COSEWIC. The COSEWIC was established by Environment Canada following a recommendation made in 1976 at a conference on endangered species co-sponsored by the Canadian Nature Federation and the World Wildlife Fund (Canada) with the objective of reviewing the status of Canadian species thought to be in danger. Its membership is now comprised of representatives from provincial and territorial wildlife agencies and delegates from a few other NGOs. As of 1990, the COSEWIC has studied the status of 250 Canadian species, subspecies or populations and classified nearly 200 species of plants and vertebrates as vulnerable, threatened, endangered or extirpated. The contribution of NGOs to the COSEWIC has ranged from financial support to scientific expertise, from political lobbying to public rallying. It is doubtful that our governmental agencies could have achieved even half of what has been done without the support of these groups.

Next to determining the status of various wildlife species, lies the immense task of recovering the most endangered ones. To this end, the Council of Canadian Wildlife Ministers established the Recovery of Nationally Endangered Wildlife (RENEW) program in 1988. This program ensures that federal, provincial, and territorial governments and the private sector are collaborating in establishing recovery programs that will remove species from threatened, endangered or extirpated status. For the first term of the committee, the private sector is represented by delegates of the Canadian Nature Federation, the Canadian Wildlife Federation and the World Wildlife Fund (Canada).

Among other responsibilities, the RENEW committee has to appoint recovery teams, approve recovery plans and establish the priority of recovery programs. Federal wildlife officials have recently agreed to include NGO representatives on endangered species recovery teams. This will help ensure that people active in conservation at the local level are fully integrated into national recovery efforts. The ambitious schedule for action adopted by the RENEW committee should result in the development of recovery plans for each of the 25 terrestrial vertebrate species designated by COSEWIC as extirpated, endangered or threatened, by Fall, 1991.

The peregrine falcon (*Falco peregrinus*) is one of those success stories made possible by the collaborative efforts of various contributors. In Quebec, the peregrine's recovery plan has benefitted so far from the collaboration of the provincial and federal wildlife and parks agencies, a raptor research center (the Macdonald College Raptor Research Center of Montreal), a raptor rehabilitation society (Union québécoise pour la réhabilitation des oiseaux de proie), a private foundation (Fondation pour la sauvegarde des espèces menacées), a citizens' committee (from Saint-André de Kamouraska), a college (CEGEP de La Pocatière), an ornithologists club (Club des ornithologues du Bas Saint-Laurent), and a good number of dedicated ornithologists. The joint efforts of all these groups have led to the recent downlisting of the peregrine falcon from the endangered to the vulnerable category for the province, following the reporting of at least 10 nesting pairs in southern Quebec (Robert 1989).

Naturalists in Atlantic Canada had started their efforts to protect the endangered piping plover (*Charadrius melodus*) long before the official recovery plan was made available in 1990. The Natural History Society of Prince Edward Island has done excellent work with PEI National Park to protect piping plover beaches. In conjunction with the Atlantic Centre for the Environment, they have produced and distributed educational posters, and a slide show on the species has been prepared and placed on videocassette. In the Magdalen Islands, two NGOs (the Mouvement pour la valorisation du patrimoine naturel des Iles-de-la- Madeleine and the Quebec Association of Ornithologists' Groups) and the Canadian Wildlife Service (Quebec branch) have established a coordinated research and public education program on the species. Without these joint efforts, the piping plover national recovery plan would not be so advanced. Other volunteer organizations across the country are doing comparable work on species of particular concern to them, often in the absence of recovery plans or formal government support.

In the United States and Great Britain, organizations like Wildlife Conservation International, Conservation International, Jersey Wildlife Preservation Trust and World Wildlife Fund raise money for conservation projects and conduct scientific studies in support of conservation worldwide. The numerous NGOs acting for conservation constitute what British conservationist Lee Durrell calls ''Noah's army'' (Burnett et al. 1989).

Zoos: Actors for Conservation

Zoos and aquariums also have a tremendous potential to contribute to regional and global conservation efforts. With over 100 million visitors a year, such institutions (there are close to 200 institutional zoos and aquariums in North America alone) are becoming an important focus of public education (Hatley 1980, Serrell 1982). Nearly 90 percent of zoos in the U.S. and Canada have an education department, and nature conservation has been the main focus of their programs for the past 10 years.

In addition, professionally managed institutions provide a haven for some endangered species, thus increasing their chances for continued survival (Prescott 1985, Soulé et al. 1986). Through innovative research, zoos have developed successful techniques to manage and breed rare animals in captivity and contributed to the recent development of the field of small population biology (*see* Foose 1983, Ralls and Ballou 1986).

In 1981, the American Association of Zoological Parks and Aquariums (AAZPA) established the Species Survival Plan (SSP), an ambitious scheme for the long term survival of endangered species through captive propagation (Wemmer et al. 1988). This goal is achieved through the coordination and strengthening of captive breeding programs. Five objectives characterize SSP programs:

1. reinforcement of wild populations in danger of extinction;
2. providing a source of animals for repopulation of original habitats if and when feasible;
3. serving as refuges for species that are currently extinct in the wild;
4. serving as repositories for germ plasm, i.e., semen, ova and embryos; and
5. providing the means to conduct research for the improvement of captive husbandry and management of wild populations.

In the interest of these goals, a masterplan is developed, for each species in the program, which generates institution by institution and animal by animal recommendations. Each SSP is directed by a Species Coordinator and a Propagation Committee selected from institutional participants. The entire program is managed by a small team employed by the AAZPA. Similar programs have been modeled after the SSP in other regions namely Europe and Australia. Recently these efforts have expanded worldwide through the efforts of the IUCN's Captive Breeding Specialist Group (IUCN CBSG) which in itself is part of IUCN's Species Survival Commission (SSC). In November 1990, AAZPA and IUCN CBSG signed a memorandum of understanding to facilitate communication and participation across organizational lines and to foster cooperation in the use of captive propagation, to assist in prevention of species extinctions and promotion species conservation in natural habitats.

In Canada, the association between the Canadian Wildlife Service and zoos has led to the successful reintroductions of captive-bred wood bison (*Bison bison athabascae*) and swift fox (*Vulpes velox*). In the United States, cooperative programs between the U.S. Fish and Wildlife Service and zoos have also proved successful. Captive-bred red wolves (*Canis rufus*) have been successfully returned to the wild and black-footed ferrets (*Mustela nigripes*) and California condors (*Gymnogypa californianus*) may soon follow.

Of the 56 SSPs currently in existence, only 6 are focused on North American endemic fauna (black-footed ferret, California condor, thick-billed parrot [*Rynchopsitta p. pachyrhyncha*], red wolf, Puerto Rican crested toad [*Peltophryne lemur*], and Virgin Island boa [*Epicrates monensis*]). Thus, with increased cooperation and funding, the potential for expansion is tremendous.

Conclusion

The effectiveness of cooperation in attaining conservation goals has been demonstrated by The Nature Conservancy since its inception in 1951 (Jenkins 1984). More recently, the value of cooperation was recognized in the first recommendation of the Terrestrial Animal Species Panel at the U.S. Strategy Conference on Biological Diversity (U.S. Dept. of State 1982) (Salwasser et al. 1987). Salwasser (1990) and Falk (1990) have further demonstrated the role of interagency cooperation and integrated strategies in managing for viable populations of plants and animals. Salwasser et al. (1987) suggested the establishment of conservation networks in order to protect and manage the large natural areas needed to sustain key species as well as the integrity of entire ecological systems. We believe that this concept should be applied to species recovery plans.

Recovery teams should identify and integrate in their recovery plans NGOs and institutions such as zoos, aquariums, botanical gardens, conservation organizations, science museums, interpretation centers, colleges and universities that could help them fulfill their mandates at the local level. The financial, scientific and/or technical contribution of private corporations should also be considered. Government authorities that oversee conservation efforts should formally recognize the contribution of NGOs and private or public institutions to recovery plans by signing memoranda of agreement. These memoranda of agreement are tipically signed by top-level organization heads, outline the responsibilities of participating organizations and thus help to avoid any misunderstanding. Such agreement would not only help to ensure long-lasting cooperation between organizations (Salwasser et al. 1987) but also could foster the contribution of other, previously unknown, partners to the immense task of conserving biodiversity.

However promising Recovery plans and SSPs may look for the protection of endangered species, these tools have many limitations in being only part of the solution. Indeed, the numbers of threatened species are increasing so rapidly that we may eventually need to create a new recovery team and program each day if not each hour. Alternatively, we need to formulate a global conservation strategy, the goals and objectives of which would be shared by all. Implementation of such a plan would certainly be dependent on finding sufficient funds. However we believe that cooperation and sharing are the fundamental keys to success.

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Special Session 4. *Recreational Impacts on Wildlife in Wildlands*

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Wildlife Preservation and Recreational Use: Conflicting Goals of Wildland Management

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Introduction

Large tracts of wildland in North America have been set aside as wilderness areas and national parks. More than 200 million acres (88 million ha) of such lands have been formally designated in Canada and the United States (Eidsvik 1989). The primary goal of these designations is the preservation of undisturbed natural conditions and processes.

Although preservation is the foremost goal of these wildlands, recreational use is usually allowed and often encouraged. Recreation use data are scant, often of poor quality and subject to misinterpretation due to changes in measurement units and number of areas reporting; however, the trend is clear. Recreational use of wilderness and national parks has increased greatly over the past half-century. Recreational use of National Forest wilderness in the United States has probably increased at least tenfold since the late 1940s, to current annual use levels of more than 12 million recreation visitor days (Lucas and Stankey 1988). In addition, the popularity of wilderness recreation in relation to other types of forest recreation has steadily increased. Wilderness use grew from 1 percent of total forest recreation use in 1946 to 6 percent in 1986. In 1946, only 5 percent of forest camping occurred in wilderness;

in 1986, 35 percent of forest camping took place in wilderness (Lucas 1989). Similar trends took place in national parks in the United States and comparable lands in Canada.

The twin goals of nature preservation and provision of recreational opportunities inevitably conflict. Recreation causes impacts to the land and the wildlife that inhabit the land. Management actions taken to mitigate these impacts frequently restrict access and recreational activities. The responsibility of the wildland manager is to determine the optimal mix of preservation and use, and to implement strategies to achieve this mix. To help the manager in this task, research on interactions between recreationists and the environment is needed.

Recreational Impact Research

The earliest study of recreational impact on natural environments, that we are aware of, examined tourist impacts on tree roots in the California redwood state parks (Meinecke 1928). By the late 1950s, a few other recreation impact studies had been conducted, including studies of the response of animals to human presence (e.g., Altmann 1958). It was in the 1960s and 1970s, however, that an increased awareness of recreational impact problems spurred a great increase in the number of studies. Worldwide, there have been about 150 published papers on recreational impact on vegetation and soils that contain original data (Cole 1987); the number of papers with original data on recreational impacts on wildlife is somewhat higher—there were 166 papers as of 1983 (Boyle and Samson 1985).

Despite all these studies, our understanding of recreational impacts is still rudimentary. Goldsmith (1974) has commented that most recreational impact studies merely "record observations of a rather superficial nature and only a few describe specially designed experiments with detailed analysis of the resultant data." Seventeen years later, this analysis of the situation still applies. Most research continues to merely document the obvious; time frames from studies are short; theory is lacking; few studies utilize experimental designs; and few studies produce results that lead to broader generalizations.

Need for Wildlife Impact Research

There are a number of reasons for thinking that recreational impacts on wildlife may be significantly compromising wildland preservation goals. The first reason, as stated earlier, is that recreational use of these lands has increased dramatically in recent decades. Second, in contrast to impacts on vegetation and soil, which are highly localized, impacts on wildlife are likely to be more widespread. Since animals are mobile, it is possible for entire populations or entire habitats to be disrupted by recreational use.

A third reason for concern is the tendency for management to promote more even distribution of recreational use, both in space and time. In most places, recreational use is extremely unevenly distributed (Roggenbuck and Lucas 1987). Use is often confined to trail corridors, with a few select trails accounting for a majority of use. Similarly, use is often confined to seasons when weather is mild, and to weekends and holidays when most people are away from work. Managers have frequently considered this concentration of use to be undesirable because it can result in high levels of crowding and resource impacts at popular times and in popular places (Hendee et al. 1990). The common response has been to attempt to disperse use more widely. Visitors are told about alternatives to the popular places or asked to avoid crowded trails and places. The attractions of off-season travel are advertised as a contrast to the crowded conditions of the high-use season and people are advised to visit on weekdays rather than on weekends.

Recreational use is still unevenly distributed, but there is evidence that use distributions have shifted. Winter season visitation in national parks has increased greatly, as have cross-country skiing and off-trail travel in backcountry. For example, total visitation to Yellowstone National Park changed little between 1965 and 1980; however, winter visitation increased tenfold (Aune 1981). Reductions in use at popular times and in popular places have seldom been dramatic. It is the increases in use of remote places and during the off-season that have been pronounced. The proportion of an area that is never visited and the proportion of the year that visitation is negligible have shrunk greatly over the last few decades—as much in response to changes in use distribution as to increases in use. The effect on wildlife is that refuge from disturbance has decreased dramatically—if low levels of recreational use have a significant impact.

The interface between humans and wildlife, particularly in regard to nonconsumptive uses of wildlife, has recently become a topic of considerable interest. Social scientists, in particular, have been organizing meetings and writing papers on the human dimensions of wildlife (Manfredo 1989). Another topic that obviously lies at the juncture of social science and wildlife management is the impact of recreationists on wildlife. The intent of this paper and of this session is to suggest that this area deserves more attention.

Information Needs

In order to more effectively minimize conflict between recreation use and wildlife preservation goals, we need to: (1) understand the responses of wildlife to recreational activities; (2) understand the factors that influence the nature and magnitude of impacts; (3) improve research methods; and (4) develop and implement new management strategies. This session is organized around these topics.

Previous research has documented numerous cases where wildlife have responded negatively to recreational use; however, it is seldom possible to determine how significant these impacts are. An ungulate may run from an approaching skier, but does that reduce the fitness of that individual or significantly affect a population—either in the short or long term? We need more research that documents the various effects of different recreational activities on wildlife; and more attention needs to be paid to impacts other than short-term behavioral changes in individuals. Are there long-term impacts? How are behavioral responses by individuals manifested at the population or community levels? This type of research is challenging because it is difficult to distinguish between natural variability in populations and variability that results from recreational use (Boyle and Samson 1985), particularly where the effect of recreation is indirect and the response occurs far from the point of disturbance or after a time lag (Goldsmith 1974).

Managers need to understand why some types of disturbance cause pronounced impacts while others have little effect. They also must understand why the same recreational activity causes serious problems in some situations and has no effect in others. Such characteristics of the disturbance as activity type, frequency and timing can influence the severity of the response. Characteristics of the animals being disturbed can also influence responses. There is a particular need to better understand learned behavior, such as the ability of animals to habituate to human disturbance. An understanding of the factors that influence the nature and magnitude of impacts will enable managers to develop more effective strategies for minimizing impact.

To obtain an improved understanding of recreational impacts on wildlife, new and improved research designs and methods are needed. As stated before, impacts are complex and it is often difficult to uncover cause and effect relationships. More experimentation is clearly needed, but confounding variables are usually difficult to control. Short-term, readily observable behavioral responses are easy to study, but longer-term investigations are needed to answer questions of significance.

The ultimate goal of this research is to see that management optimizes the twin goals of wildlife preservation and recreational opportunity. Beyond simply closing areas to all recreational use, impacts might be kept to acceptable levels through such strategies as spatial and temporal restrictions or even subtle alterations in human behavior. Besides managing disturbance agents, managers may also be able to reduce impact by managing the animal populations and the context in which disturbance occurs. Hopefully, there will also be opportunities to evaluate the success of management programs that are established.

Conclusion

It is our hope that this session will accomplish a number of goals. First, we hope that it will increase awareness of the need to improve our understanding of recreational impacts on wildlife. Wildlands are important to our society and undisturbed wildlife populations are a critical indicator of the quality of wildlands. Managers can only be as effective as the knowledge and information they bring to bear on problems. The current, poor level of understanding of this topic is clearly an impediment to effective management.

Second, we hope that the substance of the technical articles will be useful to scholars interested in working in the field and managers already grappling with impact problems. Papers that review the literature, describe available research methodologies and discuss available management options should help in this regard.

Third, we hope that through the opportunity to present these papers and the discussion that ensues, we will all learn from each other. New ideas will surface and new contacts will be developed. Substantial improvements in knowledge will only come if more researchers work in the field; more of these researchers commit more of their time and energy to the subject; and new ideas and methodologies are brought to bear. Will you—the wildlife conservation community—accept this challenge?

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Effects of Recreational Activity on Wildlife in Wildlands

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Introduction

The primary goals of our designated wildlands—preservation of nature and provision of recreational opportunities—inevitably conflict. Consequently, managers are concerned with minimizing deleterious impacts of recreationists on those lands. Here, we address impacts on wildlife and attempt to summarize information about recreational impacts on wildlife. We propose a hierarchy of responses of wildlife to recreation and describe factors that influence the nature and magnitude of these responses. We draw conclusions concerning causal mechanisms, wildlife responses, factors which influence responses, and conclude with suggestions for necessary research.

Recreational Impacts and Wildlife Responses

Causes of Impacts

We suggest there are four ways by which recreational activities can impact animals—harvesting, habitat modification, pollution and disturbance (Figure 1). Harvesting wildlife has been purported to affect age and sex ratios, alter birth and death rates, influence behaviors, and alter habitat usage (e.g., Batcheler 1968, Douglas 1971).

Recreational activities can result in habitat modification by disturbing the vegetation and soil, and changing microclimates. Examples include trail and campsite development which results in alteration of vegetation, as well as changes in light and moisture conditions and topographic modification. Blakesley and Reese (1988) reported reductions in ground and shrub nesting birds in campsites due to habitat alterations.

Another way recreational activities alter wildlife is through pollution, such as people discarding food or deliberately feeding animals. For example, as bears become accustomed to food and garbage left by recreationists, their foraging ecology has been altered. An increase in bear-human encounters has resulted in the destruction of "problem" animals. As with habitat modification, few pollution-derived impacts have widescale impacts, other than when entire populations are affected (e.g., bears), or where uncommon habitats are being contaminated (e.g., caves).

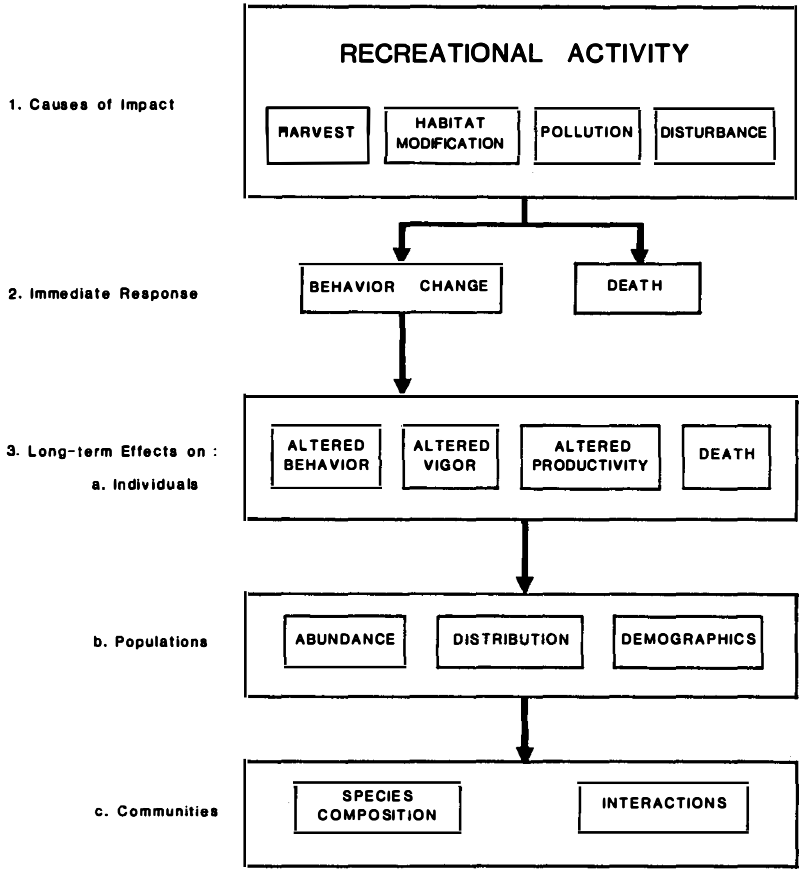

Figure 1 A conceptual model of responses of wildlife to recreational activities.

The final way that wildlife is affected by recreationists is disturbance. Disturbance can be intentional (i.e., harassment) or unintentional. Unintentional disturbance may include such things as attempting to photograph wildlife, naturalists viewing nesting birds, or hikers crossing an animal's territory. Unintentional disturbance is probably the primary means by which nonconsumptive recreational activities impact wildlife.

Immediate Responses

The most extreme immediate response of wildlife to recreational disturbance is death. Although this is the intended result of consumptive activities, nonconsumptive activities can also result in the death of animals. Snowmobiles crush small mammals that inhabit the subnivean space between snow and ground (Bury 1978), and off-road vehicles crush reptiles in the desert (Bury and Marlow 1973). Other than from consumptive activities, the direct death of wildlife is not highly significant.

The other type of immediate response is a change in behavior. All four causes of impact can alter behavior. Hunting results in waterfowl shifting their foraging patterns; modified habitats may cause birds to alter their nesting behavior; littered campsites may cause chipmunks to change their food habits; and disturbance of grazing elk can result in elevated heart rates. Most of our understanding of disturbance is confined to the immediate behavioral responses of individuals to recreationists.

Long-term Effects on Individuals

Many of the responses of animals to disturbance are short-lived. For example, deer have been found to return within hours to areas they left when disturbed by snowmobiles (e.g., Dorrance et al. 1975). Immediate behavioral responses to disturbance, however, can become long-lasting changes, or behavior can slowly change to a new state. One behavioral change is abandonment of disturbed areas in favor of undisturbed sites. This response-avoidance scenario has been shown for a number of species, including caribou (*Rangifer tarandus*) and bighorn sheep (*Ovis canadensis*) (Geist 1978). Displacement into new environments can lead to a number of further behavioral changes, such as altered feeding ecology. The opposing response-attraction has also been documented. In this case animals are attracted to recreational disturbance. Usually attraction is a response to pollution (e.g., food waste) or habitat modification (e.g., caribou following the sound of chain saws to feed on downed trees [Klein 1971]).

Disturbance can also reduce the vigor of individuals and ultimately result in death. Elevated heart rates, energy expended in disturbance flights, and reduction of energy input through disturbance will all increase energy expenditures or decrease energy acquisition. These may result in increased sickness, disease and potentially death of individuals. While these responses have been suggested, evidence is largely circumstantial (e.g., Hutchins and Geist 1987).

There are numerous studies, albeit mainly on birds, which have documented decreased productivity in response to recreational disturbance. For example, the productivity of nesting common loons (*Gavia immer*) was negatively associated with the number of human contacts (Titus and VanDruff 1981). Experimental harassment of radio-collared mule deer (*Odocoileus hemionus*) by all-terrain vehicles resulted in reduced reproduction the following year (Yarmology et al. 1988).

Long-term Effects on Populations

Consumptive recreation activities can impact the abundance, distribution and demographics of populations. Sport hunting assumes that populations show compensatory responses. Batcheler (1968) found, however, that this did not occur with hunted populations of non-native red deer (*Cervus elaphus*) and chamois (*Rupicapra rupicapra*) in New Zealand, because populations were displaced to inferior habitat.

In contrast, we know very little about how nonconsumptive recreation affects population characteristics. We can only speculate that increased mortality, reduced productivity and displacement of populations (all documented, at least anecdotally) will result in decreased populations. Localized decreases in abundance have been reported for certain ground-nesting bird species in campgrounds (Blakesley and Reese 1988), and ungulates such as bighorn sheep (Dunaway 1970). Difficulties in establishing cause-and-effect make documentation of this response problematic. Information about the effects of nonconsumptive recreation on the demographics of populations is even more scarce.

Long-term Effects on Communities

Our knowledge on the impacts of recreationists on community structure is still rudimentary. Cole and Knight (1990) described how recreation could cause alterations in species diversity, depending on the severity of recreational disturbance and the spatial scale and level of the biological hierarchy for which diversity is being described. Skagen et al. (in press) showed that human disturbance would result in decreased species diversity in an avian scavenging-guild. Disturbance which resulted in altered feeding patterns by bald eagles (*Haliaeetus leucocephalus*) resulted in less available food for other scavengers. Eagles were the only scavenger present that could open the carcasses, and therefore make it available (unintentionally) for other species to feed on.

Factors that Influence Responses

Managers should attempt to keep wildlife impacts to acceptable levels by modifying the factors that influence the nature, frequency and magnitude of responses. This means either controlling recreational disturbance or influencing characteristics of the animals that will increase their tolerance to disturbance.

Characteristics of the Disturbance

Type of activity. As noted in the previous section, different activities may elicit different responses. For example, motorized boating in Minnesota resulted in nest desertion by common loons, whereas the presence of canoe travelers did not (Titus and VanDruff 1981). Different types of recreational activities, however, may not always have different impacts. The presence of a bird watcher along a shoreline may have the same effect as an angler fishing from shore. The context in which a particular activity occurs may also influence wildlife response. For example, sound elicits a much milder response from wildlife if animals are visually buffered from the disturbance (e.g., Singer 1978).

Recreational activities should not be viewed in isolation. There may be synergisms or interactions when more than one recreational activity is occurring simultaneously. For example, at a reservoir in South Wales sailing was not detrimental to waterfowl because boats used only the deep water areas and waterfowl used shallows. When bank fishing occurred, however, waterfowl moved to the deeper central waters where they then encountered sailors. Angling and sailing, therefore, resulted in birds being deprived of any part of the reservoir (Bell and Austin 1985).

Timing. Disturbance at any time of the year can affect an animal's inclusive fitness. Disturbance during the breeding season may affect an individual's productivity while disturbance outside of the breeding season may affect the individual's ability to forge and, therefore, its survival.

The most common response to severe disturbance during the breeding season is nest or young abandonment, which can lead to total reproductive failure (e.g., White and Thurow 1985). Disturbance during the breeding season can have different affects based on when during the reproductive phenology it occurs. For example, some researchers have attributed lowered reproduction in nesting ospreys (*Pandion haliaetus*) to human disturbance (e.g., Swenson 1979), while others (e.g., Poole 1981) found no relationship between disturbance and nesting success. Disturbance during the incubation period resulted in greater reproductive failure than disturbance during the nestling period.

Disturbance can cause adults to temporarily leave their nest or den sites. Reduced parental attentiveness can increase the risk of young being preyed upon, disrupt feeding patterns, or expose young to adverse environmental conditions. If parents are disturbed from their nests, and are reluctant to return, then predators may visit the nest and consume eggs or young (e.g., Verbeek 1982).

Outside of the breeding season animals are not restrained to a nest or den site, nor are young as dependent upon their parents. Wildlife, however, still respond to disturbance, thereby potentially reducing energy acquisition (i.e., foraging) or increasing energy expenditure (i.e., fleeing) (Owens 1977, Stalmaster 1983). Stalmaster (1983) prepared an energetics simulation model which quantified the effects of recreationists on wintering bald eagles in the Pacific Northwest. His model predicted that land- and water-based disturbances that resulted in avoidance flights cost eagles 0.0359 kcal and 0.359 kcal, respectively. If 30 land and water activities occurred daily at a winter feeding site for 30 days while 300 eagles were present, 106,623 kcal would be expanded in human-disturbance related avoidance flights, thus reducing the area's carrying capacity by 217 eagle days.

Location. The spatial context in which disturbance occurs can influence the response shown by wildlife because of the degree of threat or security posed by the spatial arrangement. For example, bighorn sheep showed stronger reactions to hikers approaching from above than to hikers approaching from below (Hicks and Elder 1979). Animals also appear to feel safer when they have greater open distance between themselves and potential threats. Pink-footed geese (*Anser brachyrhynchus*) in Denmark avoided areas where vegetation or topography hindered their views (Madsen 1985).

Frequency. The number of disturbance bouts that occur during a time interval can influence wildlife responses. For example, birds whose nests were visited frequently had lower reproductive success than those visited infrequently (e.g., Bunnell et al. 1981). There appear to be thresholds of disturbance frequencies where measurable wildlife responses occur. Recreation intensity values between 7.8 and 37.0 visitors ha^{-1} resulted in decreased bird densities in the Netherlands (van der Zande and Vos 1984). Belanger and Bedard (1989) found that when disturbance exceeded 2.0/hr, it resulted in a 50 percent drop in the mean number of snow geeses (*Chen caerulescens*) present the following day.

Predictability. When disturbance is predictable and benign, it causes little response. Chamois appeared to habituate to humans as long as the intruders' activities remained spatially and temporally predictable (Hamr 1988). Disturbance which is threatening (e.g., active persecution), albeit predictable, would result in a different type of response from wildlife. For example, the level of wariness of a flock of birds feeding in a particular area depends on the tradition of disturbance in that area (Owen 1972, Knight and Knight 1986, Madsen 1988).

Characteristics of the wildlife being disturbed. The number and composition of wildlife groups may influence the response to disturbance. For example, animals feeding in groups respond to approaching threats at greater distances than solitary individuals (e.g., Owens 1977, Madsen 1985). These variations in flight distances are due to differences in tolerance among flock members. There is an increased likelihood that larger groups will contain individuals who are more sensitized to humans and will flee at a greater distance thereby causing other group members to also flee. Likewise, the time devoted to vigilance by feeding individuals decreases as flock or herd size increases (e.g., Caraco et al. 1980).

Age and sex of individuals may also influence wildlife responses to recreationists. For example, caribou cow/calf groups are more likely to flee than cow groups, and bulls are the least likely to frighten (Singer and Beattie 1986). Male chamois are more tolerant of disturbances than females, and females with kids escape sooner and withdraw further than yearling females or females without kids (Hamr 1988).

Wildlife response to disturbance also correlates with species' body size. Smaller species have both lower flushing responses and shorter flushing distances than larger species (Cooke 1980, Skagen et al. in press). This relationship has been attributed to both energetic considerations (e.g., surface area-to-body volume ratios) and persecution histories (e.g., larger animals more heavily persecuted than smaller animals; Knight 1984, Knight et al. 1989).

The nutritional state of an animal also influences its response. Researchers have suggested that malnourished individuals are less likely to flush, and flush at shorter distances than do individuals in good nutritional condition (e.g., Knight and Knight 1984, Hamr 1988). Processes influencing energy intake during winter have a much greater impact on energy balance of ungulates than processes affecting energy expenditure (Hobbs 1989). This suggests that disturbance which disrupts feeding wildlife should be of greater concern than disturbance which causes wildlife to flee.

Origin of Responses of Wildlife to Recreationists

Learned

A review of wildlife responses to human activities reveals an enormous amount of both intra and inter-specific variation. Peregrine falcons (*Falco peregrinus*) in New Mexico showed 22-fold differences in the distances at which they responded to similar stimuli (Johnson 1988). Suter and Joness (1981) reported 45-fold differences in flushing distances among three raptor species. Moose (*Alces alces*) in Denali National Park were more alert to vehicle traffic than were caribou (Singer and Beattie 1986).

This variation in intra- and inter-specific responses to disturbance has both innate and learned components. The learned component has been attributed to the number and outcome of interactions between individuals and stimuli over the individual's lifetime (e.g., Knight and Temple 1986a). King and Workman (1986) felt that deset bighorn sheep increased their avoidance responses to human beings with an increasing number of negative encounters. Three species of songbirds whose nests were repeatedly visited by researchers became significantly more aggressive over time (Knight and Temple 1986a, 1986b). Parent birds at nests visited only once, but at equivalent time periods during the nesting season, did not show elevated levels of aggressiveness.

Geese show increased wariness with an increase in harassment (Owens 1977, Madsen 1985).

Three categories of learned responses wildlife show to recreationists are avoidance, attraction and habituation. Habituation is defined as a waning of a response to a repeated stimulus which is not associated with either a positive or negative reward. A positive reward would result in attraction, whereas, a negative stimulus would result in avoidance (Eibl-Eibesfeldt 1970).

Knight et al. (1987) took advantage of a natural experiment to see whether American crows (*Corvus brachyrhynchus*) habituated to humans in an area of high human density and low persecution (i.e., cities). They hypothesized that in the absence of persecution, but in the presence of high human activity, crows would have to habituate in order to complete their daily activities. They compared the responses to crows to humans on the ground both in a city and in a rural area, where crows were actively persecuted. Crows in the city ignored humans on the ground indicating they had habituated to nonthreatening activities, whereas rural crows showed strong avoidance behavior.

Attraction is when an individual seeks out human beings because of rewards or positive reinforcement. Attraction may alter some important aspect of the animal's behavior, such as foraging, which could alter the animal's survival. Until the early 1970s, a portion of the grizzly bears (*Ursus arctos*) in Yellowstone National Park subsisted, to varying degrees, on human food wastes at garbage dumps within the park. Following the sudden closures of the dumps there were expansions in the size of bear home ranges, and decreases in body size, reproductive rate and average litter size (Despain et al. 1986). The change in nutrition from human food wastes to natural foods may explain a number of these life-history differences. In addition, bears had to relearn skills required to obtain live prey and carrion.

At the extreme view of this argument, there is the possibility that altered behavior of a keystone species could even alter an ecosystems. Tomback and Taylor (1986) studied Clark's nutcrackers (*Nucifraga columbiana*) at scenic turnouts in Rocky Mountain National Park where nutcrackers gather to feed on food provided by tourists. Nutcrackers are an important dispersal agent for limber pine (*Pinus flexilis*), a common species in the subalpine ecosystems of the Front Range of Colorado. If tourist activities discouraged normal nutcracker seed harvesting and storing activities, and altered the distribution of free-ranging individuals, then a decline in afforestation rates is possible.

Whereas animals might be expected to habituate to a benign stimulus, or be attracted to one with a reward, they should learn to avoid a stimulus associated with pain or punishment. Grizzly bears in Glacier National Park moved away immediately from people only 5 percent of the time, whereas, in a nearby area where they were persecuted, bears always moved away immediately, and on most occasions, they fled >1 km (McLellan and Shackleton 1989). Both common ravens (*Corvus corax*) and American crows nesting in areas of high persecution were more timid and showed stronger avoidance behavior and lower nest defense than birds in areas of low persecution (Knight 1984, Knight et al. 1987).

Genetic

In addition to learning, animals have a genetic component affecting their responses to stimuli. Animals are genetically predisposed to certain behaviors which are in turn influenced by environmental factors (Hailman 1967, 1969). For example, bighorn sheep and mountain goats (*Oreamnos americanus*) withdrew to cliffs when they heard sudden loud noises, apparently an innate response to avalanches and rockfalls (Geist 1971, 1978). This genetically determined behavior can be reinforced through learning by the discharge of firearms in a hunted population.

Newton (1979) hypothesized that intraspecific differences in nest-defense behavior of Falconiformes were due to past levels of human persecution. If shooting disproportionately eliminated aggressive birds, then nest-defense aggressiveness would vary with the history of persecution in an area. Newton implied that natural selection was the mechanism that modified a species' behavior. Knight et al. (1989) compared nest-defense behavior in seven widely separated populations of red-tailed hawks (*Buteo jamaicensis*) in North America that differed in the number of years since European settlement (range: 75–215 years). Length of European settlement was assumed to correlate positively with the duration of active persecution. Birds in areas settled the longest were the most timid to human intruders suggesting a genetic component to their behavior.

Conclusions

Given the present state of our knowledge, there are gaps in our information which are readily apparent and that can be resolved only through well-designed studies which examine wildlife at different hierarchical scales. For example, we need to understand how recreation activities affect the inclusive fitness of individuals, and, in turn, whether populations and communities are impacted. If animals are denied access to areas that are essential for reproduction and survival, then that population will decline. Likewise, if animals are disturbed while performing essential behaviors, such as foraging or breeding, that population will also likely decline. If recreational disturbance does alter animal populations, then one must assume this response may alter the dynamics of a wildlife community. Accordingly, research on community structure and the role of recreational disturbance may yield some potentially important findings regarding the overall health of ecosystems.

There is an overwhelming need for studies which document the learning and decay rate of attraction, habituation and avoidance behaviors in animals. Ideally, these studies should be conducted on a variety of species which offer the full diversity of life-history strategies. Likewise, we need a better understanding of how the behavior of recreationsists influences the predictability and perceived threat of these activities to wildlife. This information would allow human management that promoted habituation by wildlife, which would, in turn, decrease negative impacts.

What happens to wildlife following disturbance? Since wildlife will not readily habituate to all types of recreation, where do animals go following disturbance? This question relates to both energy acquisition and habitat use. Are individuals able to compensate for lost foraging opportunities? What are the implications of crowding of individuals into remaining habitat if recreation causes previously suitable habitat to become unacceptable?

The pressures of recreational activities on wildlife in wildlands will not soon diminish. Responsible wildland management necessitates that we fully understand the numerous dimensions of recreation and wildlife. Although progress in this field to date has been slow, we are beginning to develop a conceptual model of the interrelationships between the two and can anticipate rapid conceptual advances in the years to come.

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Assessing Recreational Impacts on Wildlife: The Value and Design of Experiments

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Introduction

A variety of research approaches can be fruitful in assessing recreational impacts (Cole 1987). Two types of studies that have been used by wildlife scientists are observational (nonexperimental) and experimental. Observational research is frequently more convenient and less expensive than conducting field experiments. For example, a single person could study hiker impact on bird distributions by monitoring trail use and periodically sampling bird populations along these trails. Associations between different aspects of hiking (e.g., number of hikers, frequency of trail use, seasonal timing) and bird abundances could then be determined. The same project conducted as an experiment would cost considerably more if "hikers" were research personnel instead of the public. This would be the case if, to control for extraneous sources of variation, hiking needed to be regulated at specified frequencies or times and implemented with a fixed protocol. An experiment thus could place additional demands on budgets for salaries, time, vehicles and, perhaps, other resources. Observational studies can be convenient and inexpensive too because data collected during earlier efforts (e.g., trail registers in this hiker example, or prior bird censuses) or from a variety of sources (e.g., different comparable studies) can be combined to explore for impact relations.

Observational studies are advantageous when logistical difficulties and resource constraints cannot be overcome to conduct experiments. Sometimes, observational work is the only realistic way to obtain data. This is especially true when time is a limiting factor, as it is when decisions about how to preserve rare, threatened or endangered species must be made quickly. In a pinch, analysis of existing observational data may be the best option; conceivably, a species could go extinct while we design and execute an experiment we deem necessary. Observational research also can make use of data from a variety of systems, enabling one to do comparative analyses that will help identify pervasive relations (Franklin et al. 1990). Prohibitively complex and expensive experiments may be required to gather data over the same temporal and spatial scales as an observational effort of the same scope and intensity.

Despite these advantages, observational research has important limitations. In such studies we can only identify associations; causal relations cannot be established. This is true of observational studies that attempt to control for nuisance variables as well. Knowledge of associations alone may not be adequate to solve a management problem. And the influences of recreational activities on wildlife may have many aspects that are completely confounded. Consider, for instance, how one might determine the impact of off-road vehicles (ORVs) on wildlife habitat use. If observational data on habitat use for ORV areas were compared to those for control (ORVs prohibited) areas, one would not be able to determine whether changes in habitat use were due to associated vegetation destruction, noise, or the presence of people. Only well-designed experiments enable us to identify causal agents.

In many situations, field experiments are realistic alternatives to observational studies (*see* Macnab 1983, Walters and Holling 1990). By taking advantage of ongoing management activities, biologists have many opportunities to conduct inexpensive experiments to assess recreational impacts. Wildlife and recreation managers, with the aid of land-management agencies, can regulate the public's use of particular areas to manipulate levels of a recreational activity of concern. Depending on the agencies' holdings, large amounts of land could be involved in experiments. This would improve the biologist's ability to meet experimental design standards, such as adequate replication and temporal and spatial controls; the applicability of the experiment's results also would be broadened by involving many sites. It can be difficult to design and execute experiments that truly simulate recreational activities (Cole 1987). But this problem can be surmounted by ensuring that planned treatments are identical to the recreational activity in question. My objectives in this paper are (1) to emphasize the practical and scientific value of field experiments in recreational impact assessment, and (2) to offer advice about how such experiments should be designed to maximize their interpretability.

The Value of Experiments

Well-designed experiments help establish causal relations, which can then be used in a variety of ways to understand and manage recreational impacts on wildlife. The more clearly we understand impact processes, the better chance we will have to solve impact problems. Armed with knowledge about associations only, one may manipulate or curtail aspects of recreational activities that have little or no bearing on the problem. This may produce additional problems for wildlife, generate serious complaints about resource availability from the public, or both. The most efficient way to advance our understanding of impact problems is to conduct sound experiments (*see* Romesburg 1981, Macnab 1983, Boyle and Samson 1985). Comparable experiments repeated at different places and times—in different contexts in general—may help uncover general patterns that could be used to solve problems in many areas, not just on our own study sites. If managers can identify underlying principles concerning responses to certain recreational activities, they will be better able to predict and thus avoid impacts. Knowledge about causal factors may decrease the amount of money, time, and effort needed to alleviate an impact problem by enabling managers to act on the source of the problem quicker. The period of stress on wildlife resources would thus be shortened, and management funds would be spent more effectively. Correlations and other forms of association may be helpful in solving a problem. That is, it may not always be necessary to identify causal factors. The extent to which this is true, however, will depend in part on how well associations incorporate causal agents. If true causal factors are not even correlated with variables we think are producing impacts, then efforts to solve a problem may be inefficient at best.

Experimental Design

Statistical Considerations

Conventional aspects of experimental design, including sampling, controls, replication and statistical power analyses, are relevant in the design of experiments to assess recreational impacts. Abundant, practical literature on these topics is accessible to those who have taken one or two statistics courses. Cochran (1977), Green (1979), and Hairston (1989) provide advice about presampling, sampling, and temporal and spatial controls. Power analyses for a variety of techniques used to analyze experimental data are discussed by Cohen (1977) and Zar (1984). And Hicks (1973), Milliken and Johnson (1984), and Ott (1988) address the issues of analysis of variance and follow-up procedures. I will not discuss these topics further because the works I have cited are excellent. Instead, I will discuss four design considerations that have not received adequate attention by investigators in this field and that have special relevance for recreational impact experiments.

Covariates. In recreational impact experiments, no two experimental units (e.g., forest stands, individual animals, litters) will be identical. Differences among units may lead to variation in responses to recreational activities that can obscure true impacts. If such differences are controlled for (analytically or via the study design), however, the true effects of recreational activities and impacts on wildlife are more likely to emerge. Analysis of covariance enables one to account for differences among experimental units before assessing main and interaction effects. In so doing, this technique can improve the statistical power of an analysis (i.e., its ability to detect a significant effect). For each covariate used, one degree of freedom is lost, leading to a slight decrease in power. This small decrease is likely to be offset, however, if the covariate is associated with a large fraction of the variation in the dependent variable. A conservative approach in the use of covariates is to use the single variable most correlated with the dependent variable, and for which the assumptions of analysis of covariance can be met. Several potential covariates could be measured and the one that best meets these criteria could be used. When more than one covariate is used, assumptions of analysis of covariance are more difficult to meet, and the potential for statistical problems (e.g., multicollinearity) increases. Statistical power is not likely to be improved appreciably if a covariate is not significantly associated with the dependent variable; the analysis also will be misleading if the covariates used violate important statistical assumptions. Huitema (1980) provides extensive practical advice about all of these issues and parametric and nonparametric approaches to analysis of covariance. Some useful covariates in recreational impact experiments might be: habitat features that influence the richness or abundance of species; whether there has been previous exposure to recreational disturbance; social context of the animals in question; sex (e.g., Baydack and Hein 1987) and age; and distance to nearby undisturbed habitat (*see also* Hammitt and Cole 1987). Random selection of experimental units, and random assignment of treatments to those units will help balance many extraneous effects on the dependent variable and avoid associated biases. Randomization also will obviate the need for many covariates and simplify interpretation of the experiment's results.

Interaction effects. Many facets of recreational activity and the contexts in which they occur have the potential to interact and affect wildlife. In general, the effect of one aspect of disturbance on wildlife might depend on the level of another aspect of disturbance. For example, the effect of the frequency of human intrusion on site use by breeding birds varies with the spatial scale of intrusion (Gutzwiller in preparation). One might also expect the higher levels of two different aspects of disturbance (e.g., number of visitors, visit duration) to affect sensitive wildlife more severely than when one of the aspects is occurring at the higher level and the other at a lower level. Knowledge of interaction effects may provide insight into cumulative effects of recreational disturbances on wildlife. The impacts of fishermen and hikers together, for instance, may be different from those for one of these groups alone. In many situations, the analysis of interaction effects also is more realistic because different aspects of recreational activities probably act synergistically or antagonistically, relative to one another, on the dependent variable (wildlife response).

Modified statistical tests. A third statistical topic that warrants careful attention is when the variability of responses by wildlife can be expected to increase as a consequence of recreational impact. This may arise because of differences in responses to recreational disturbance among experimental units (e.g., individuals, herds, etc.) in the treated group (cf. Brownie et al. 1990). Higher variance in the treated group, relative to control units, can reduce the statistical power of t and F tests used to assess differences between or among mean wildlife responses. Brownie et al. (1990) have introduced modified t and analysis of variance F tests that circumvent this problem by using variances computed from controls only, instead of using pooled error variances. If you expect recreational activity to increase the variability of responses by wildlife, consider using one of these modified tests because your ability to detect recreational impacts will be improved. Use of control variances in test statistics also is applicable for Dunnett's procedure (Brownie et al. 1990), which is used to compare each factor level mean with a control mean. Brownie et al. (1990) caution that to avoid bias the decision to use a modified test should be made *a priori*. This requires that the investigator have an empirical or theoretical basis for expecting the variability of responses to be higher for the treated group. Such information may originate from prior observations of similar or related wildlife responses, or from theoretical predictions.

Independent observations. Except in experiments involving paired differences or repeated measures (Ott 1988), measurements of experimental units are assumed to be independent. Hurlbert (1984) describes how the quality and interpretability of ecological field experiments are ruined when this assumption is violated, and he provides guidance on how to design experiments that preclude this problem. The message for scientists who plan to assess recreational impacts is to ensure that experimental units and their associated responses to recreational activities are independent. Experimental units should exist far enough apart in time and space that the response by (or associated with) one unit will not influence or be correlated with that of another unit. Basic autecological knowledge, including home range and territory sizes, seasonal movements, and habitat preferences, will help one identify appropriate units. This will be especially important to consider when one assesses the impact of recreationists on site use by wildlife because most species are quite mobile.

Biological Considerations

Nonstatistical facets of experimental design can significantly influence assessment of recreational impacts too. One of these involves the biology of the organisms under study. To illustrate the importance of biological considerations and to alert investigators to influential phenomena that are often overlooked, I will discuss five behavioral or ecological issues that should be considered during experimental design.

Lags in wildlife responses. Displacement, lower reproduction, or increased mortality may not occur or be evident for days, weeks, months, or years after disturbances. Displacement from particular sites may be delayed by site tenacity (Wiens et al. 1986), high resource levels at those sites, or lack of acceptable habitat nearby. Effects of recreation-induced stress may show up months later in the form of lower reproductive output (*see* Geist 1978). And stress induced by recreational disturbance may exacerbate the effects of disease and competition and lead to higher mortality well after disturbances occur. Researchers not cognizant of potential lags might incorrectly conclude that impacts have not occurred. To minimize this problem, one should lengthen the monitoring phase of experiments so that lags will be detected more readily. Whenever possible, the duration of experiments should match species' life spans. Long-term experiments will be necessary to assess impacts associated with successive cohorts.

Habituation to recreational activities. Many species habituate to human activities (Hammitt and Cole 1987). But this may occur only at specific levels of disturbance, and disturbance intensities below or above these levels may be detrimental. Suppose, for example, that breeding birds are displaced by low-frequency human intrusion because intrusion frequency is inadequate for individuals to discern that an intruder is not a potential predator. At a higher frequency of intrusion, however, individuals are not displaced. That is, suppose birds habituate to frequent intrusions that are not associated with detrimental impacts such as nest or adult predation. An experiment involving just this higher frequency of intrusion would indicate that breeding birds habituate to intruders, whereas an experiment involving both levels of intrusion frequency would better define the ranges of intrusion frequency at which displacement and habituation occur. Investigators should therefore try to experiment with several levels of a given recreational activity because habituation may not occur at all levels. This design consideration is relevant for all aspects of a recreational activity, including its location, daily and seasonal timing, spatial scale, frequency, periodicity, and duration.

Sizes of home ranges and territories. If the scale of recreational disturbance is small relative to species' home range or territory sizes, one might expect there to be little effect. In such situations, individuals will probably be able to secure enough resources and protection from weather and predators that loss of part of their home ranges will be inconsequential. An exception might occur when a limited critical resource is located in a small area where recreational activity also is displacing wildlife. If, on the other hand, the spatial extent of detrimental disturbances encompasses entire home ranges or several home ranges, we would expect more serious impacts. These spatial considerations can be incorporated into the design of experiments by first deciding which wildlife activities (e.g., breeding, feeding, resting) are to be examined. The size of the sites (experimental units) to be treated can then be based on estimates from the literature or field observations of areas needed for that particular activity. An experiment to assess the effects of recreational activity on territory occupancy by small passerines would use much smaller sites than such an experiment for large mammalian predators for example.

Wildlife responses to subtle stimuli. Animals can react to very subtle stimuli, and unless we control for all behavioral influences except those of interest, our experimental results will not be clearly interpretable. Examples of subtle influences to which wildlife may respond include clothing color (Hammitt and Cole 1987), whether an intruder is familiar (Knight and Temple 1986), the direction of one's visual attention (Knight and Temple 1986), and whether an intruder's approach is direct or tangential (Burger and Gochfeld 1981). These and other aspects of recreational disturbance have the potential to increase the variability of responses by wildlife. When this occurs the statistical power of an experiment can be reduced. Effects inconspicuous to the investigator also could be completely confounded with treatments. Random assignment of investigators or other sources of extraneous variation to experimental units will help balance such influences and avoid biases. These problems also can be minimized by ensuring that those who administer treatments follow a very specific protocol. Protocols should be free of all known or potential causes of extraneous variation in wildlife responses.

Wildlife responses to capture and marking. Simultaneous analysis of both impact patterns and processes may render a study uninterpretable. Consider an experiment designed to assess the effect of repeated visits by ecotourists on site use by a territorial species. One could estimate the use of specific sites by the species with a censusing technique that had little or no effect on its behavior. Data for sites receiving no visits and for sites receiving visits at various levels of frequency could then be compared to assess the impacts. With this approach the pattern of response to the frequency of repeated visits could be determined, but the processes by which the patterns developed would remain unknown. It would not be possible, for instance, to ascertain whether sites with low use were abandoned initially by the species and never occupied again, or whether they were repeatedly occupied by new individuals and almost immediately abandoned because of repeated displacement by ecotourists. Data on the movements of telemetered or marked individuals would be needed to determine the processes responsible for site-use patterns. It is quite possible, however, that the mere capture and marking of an individual could cause it to abandon its territory or avoid the part of its territory in which it was caught. These effects might in trun influence estimates of site use by the species. Thus, when simultaneous study of pattern and process causes interpretation problems because of species' reactions to capture and marking, and when resources are not available for two separate studies, researchers will have to decide which type of study will best meet their objectives. Remember too that it may be sufficient to know that there is a cause-and-effect relation between a given recreational activity and wildlife responses. That is, knowledge of the process by which a pattern develops may not be critical, although this information would certainly improve our understanding of recreational impacts on wildlife.

General Recommendations

Great potential exists to establish facts about the effects of recreational activities on wildlife because, compared to other biotic sources of disturbance (e.g., disease, predation), we can experimentally manipulate anthropogenic disturbance rather easily. We should consider areas used for recreation to be treated sites and compare impacts there to those on control sites. Experiments involving different aspects of recreational disturbance, including spatial scale, frequency, periodicity, duration, and seasonal timing, are needed to understand fully how recreational activities affect wildlife. The history of recreational disturbance for sites, herds, individuals, and other experimental units can be extremely difficult to ascertain. Nevertheless, serious efforts to obtain such data are warranted because past events can significantly affect the results of current experiments; local and regional processes, involving changes in habitats and animal populations for example, also may be influential (*see* Ricklefs 1987). Experiments that assess long-term and cumulative impacts will be especially valuable because so little is known about these kinds of effects, and because such effects occur in wildlands. Under these circumstances, short-term experiments will not provide adequate information to understand or solve impact problems (*see also* Likens 1989, Magnuson 1990). We should seek a better understanding of problems that occur on broad temporal and spatial scales or that occur frequently (e.g., human intrusion) because they have the potential to influence wildlife in large regions. Scientists may be forced to postpone efforts to solve these pervasive problems so that more local and immediate crises can be resolved in time. Work to conserve endangered species is a prime example. Through experiments we should try to develop generalizable principles, predictions, and solutions regarding recreational impacts. At the same time, it will be valuable to recognize that these goals may be difficult to attain because many impacts are context-dependent (D. B. Fagre personal communication: 1990). Finally, in the design of experiments, one must be vigilant about influences that compromise the interpretability of results. In these ways we will advance our ability to understand, manage, and avoid recreation-induced impacts on wildlife.

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The Use of Heart Rate Telemetry in Assessing the Metabolic Cost of Disturbances

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Though the observed actions of men hide their real thoughts and feelings, these are revealed by the observation of their hearts

(Gantt 1960)

Introduction

Many studies have shown that various stimuli, including disturbances by people, elicit heart rate (HR) changes in animals (Thompson et al. 1968, Lynch et al. 1974, Roshchevskii et al. 1976, Moen et al. 1978, MacArthur et al. 1979, Ball and Amalner 1980, Geist et al. 1985, Diehl and Helb 1986). Moreover, HR responses can often be detected in the absence of overt behavioral responses (Thompson et al. 1968, Tatoyan and Cherkovich 1972, Holmes et al. 1976, MacArthur et al. 1979, Ball and Amlaner 1980, Ferns et al. 1980, MacArthur et al. 1982, Zimmer 1982, Diehl and Helb 1986), making HR telemetry a more sensitive technique than behavioral observation alone to study the reaction of animals to stimuli in their environment.

Although the identification of stimuli which produce HR or behavioral responses in wild animals is useful, it is more important yet to evaluate the cost of such responses. Increased vigilance and withdrawal responses involve costs which I call "lost opportunities," such as less time available for foraging or breeding activities, as well as temporary or even permanent habitat loss, all of which can affect reproductive output. Wildlife can also incur energetic expenditures during disturbances. Withdrawal responses obviously impose the energetic cost of locomotion. But even disturbances which elicit little or no behavioral responses can be energetically costly: the metabolic rate (MR) of animals exposed to new experimental procedures is elevated, but is reduced after training (Webster and Blaxter 1966, Graham 1968, Wooley and Owen 1977). Floyd (1987) and this study give more direct evidence that excitement increases energy expenditure.

Energy consumption is difficult to measure in wild animals. Furthermore, transient changes in MR, like those which are expected during disturbances, require a technique with a very short response time. Indirect calorimetry or the measurement of cardiac output and oxygen content of arterial and venous blood meet this requirement, but both are limited to the laboratory. Many studies, however, have shown that HR and MR are well-correlated in many species of animals (Bradfield et al. 1969, Owen 1969, Morhardt and Morhardt 1971, Wooley and Owen 1977, Flynn and Gessaman 1979, Pauls 1980), including ungulates (Webster 1967, Holter et al. 1976, Yamamoto et al. 1979, Nilssen et al. 1984, Fancy and White 1985, Renecker and Hudson 1985, Fancy and White 1986, Purwanto et al. 1990). Unfortunately, although few studies report energy consumption and HR during arousal, what data are available suggest that the relationship between HR and MR established with calm subjects breaks down when they become excited (Blix et al. 1974, Flynn and Gessaman 1979, Gliner et al. 1979, Turner and Carroll 1985, Allen et al. 1986, Schwaberger 1987, Miller and Ditto 1988). The common theme of these studies is that HR increases during arousal are not justified by the increases in energy expenditure.

The objectives of this study are to determine if there is a relationship between MR and HR when elk (*Cervus elaphus canadensis*) are subjected to arousing stimuli and, if so, to compare this relationship to those established for calm, inactive elk and exercising elk.

Materials and Methods

This study was conducted at the Ministik Wildlife Research Station, 48 km southeast of Edmonton, Alberta, using six trained female elk.

The HR-transmitter described in Johnston et al. (1980) was modified with a new enclosed antenna and lithium batteries, to increase its effective life. The transmitter was stitched to a lightweight nylon harness and sat on the back of the animals. A three-element yagi receiving antenna fed the signal to a receiver (AVM LA–12). The ECG signal was stored on one channel of a stereo tape recorder (Sony TC–158SD or Sony TC–D5) while a verbal description of behavior was stored on the other channel. In the lab, the signal was played back into a decoder/peak detector connected to a computer which measured the time between QRS complexes. HR in beats per minute (bpm) was based on the average interbeat interval for one minute (Chabot et al. in press).

MR was estimated from oxygen consumption ($\dot{V}_{O_2}$, l/min), using a custom-built mask to collect respiratory gases and a continuous flow indirect calorimetry system to assess $\dot{V}_{O_2}$. To eliminate some of the variability due to breathing patterns, the readings of $\dot{V}_{O_2}$ taken every 2 seconds were first subjected to a 29-point moving average, and then averaged every minute.

HR and MR of calm animals varied as a function of date, fasting time and treadmill work. Various stimuli (playback of elk, wolf and other sounds, predator and novel odors, approaches by human beings) lasting one minute were used to increase alertness.

Results and Discussion

In individual trials, HR tracks $\dot{V}_{O_2}$ well (Figure 1), although it is clear that the relationship between the two variables is different during walking than during arousal. As mentioned previously, many studies suggested that HR responses during arousal appear exaggerated relative to walking trials with similar energy requirements. In other words, when animals are walking the oxygen pulse ($\dot{V}_{O_2}$/HR) is higher (i.e., more oxygen is consumed for each heart beat) than when they are either standing calm or standing aroused. To confirm this statistically, I selected a subset of the data to minimize problems with autocorrelation. Only one data point for standing calm was selected from each trial, the fourth minute of recording (no more than two trials of 30–60 minutes were performed on a given day for each animal). Similarly, only the fourth minute of recording was selected for each speed on the treadmill (1–4 speeds per trail). As for arousal trials, only those which elicited significant trachy-

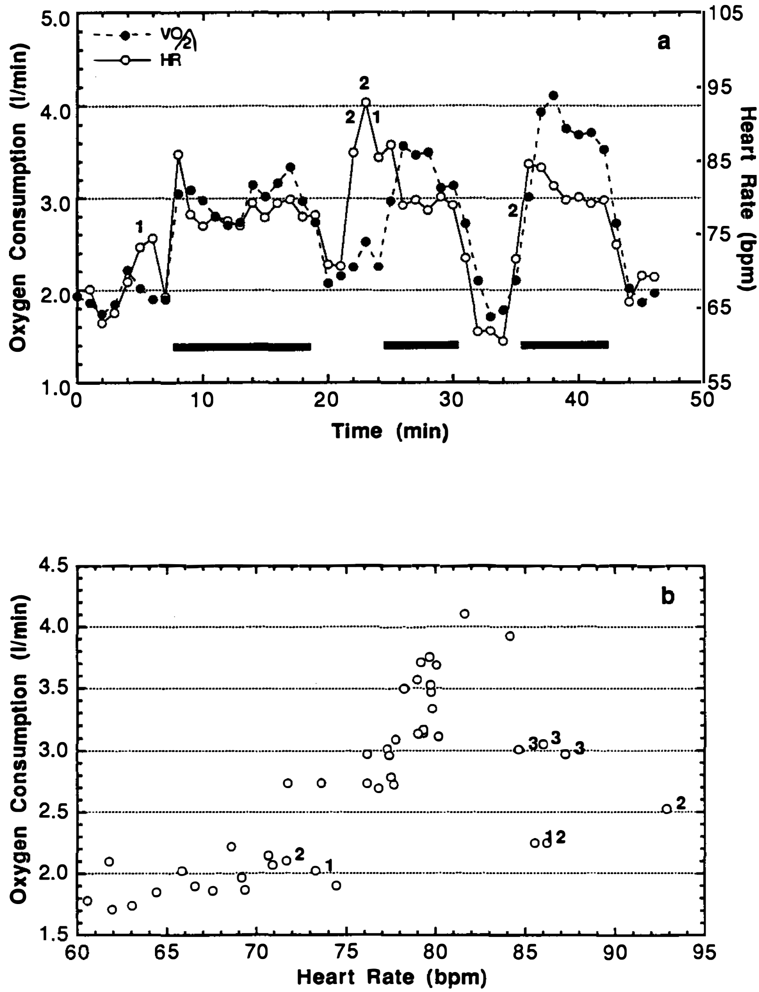

Figure 1. (a) Changes in oxygen consumption and heart rate of Ebony during a trial involving walking and some arousing situations. (b) Association between oxygen consumption and heart rate for the same trial. Thick horizontal bars indicate walking. 1 = slope of treadmill being changed. 2 = approach by a human. 3 = first minute of a walking bout.

cardia were selected, based on the distribution of HR changes from minute-to-minute in calm animals. These data were subjected to a two-way Anova on oxygen pulse (OP), with one fixed effect (category, three levels) and a random effect (animal, six levels). Category, animal and the interaction were all highly significant ($p < 0.0001$). Despite the significant interaction term, oxygen pulse was always higher during walking (Figure 2) than during the other two categories, and this was significant in a multiple comparison of means (Scheffe's S at $\alpha = 0.05$, mean OP when standing in stall and during stimulus were not different from each other, but were different from OP during walking).

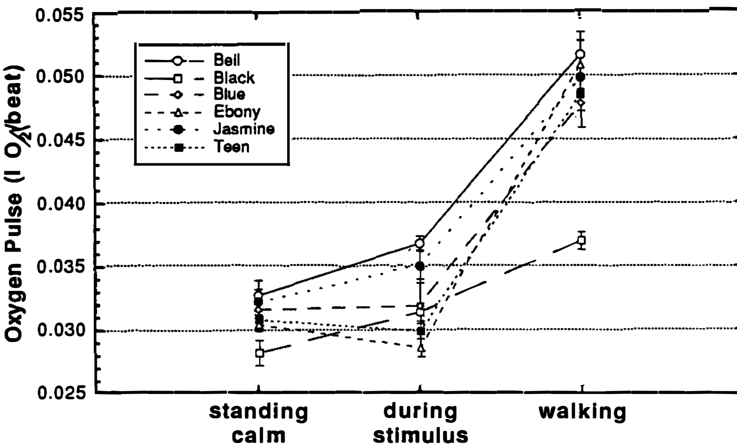

Figure 2. Comparison of the oxygen pulse of each animal (mean and SE) when standing calm, exposed to a one-minute stimulus and walking.

Only two other studies (Floyd 1987, Iwanaga et al. 1988) explored the possibility that HR could still be used to predict $\dot{V}_{O_2}$ during arousal. Floyd found that both variables increased when caribou (*Rangifer tarandus granti*) were stimulated with tones or their own calves, but that the relationship between them, or between increases in $\dot{V}_{O_2}$ and increases in HR, was poor. Iwanaga et al., on the other hand, calculated two regressions between $\dot{V}_{O_2}$ and HR for each subject: one for video-watching and another for work on a bicycle ergometer. As expected, r^2 were very high during exercise (0.931–0.949). But this is the only study I know where a significant relationship between $\dot{V}_{O_2}$ and HR has been established during arousal, even if r^2 were much lower (0.071–0.297) than for exercise. As would be predicted from other studies, the slope was less during video-wathcing. Figure 1b and further results below show this is also true for my results.

It should be pointed out the Floyd (1987) measured HR and $\dot{V}_{O_2}$ every 0.5 seconds. It is reasonable to assume that changes in the former can take place faster than changes in the latter. In addition, variations in breathing patterns can introduce noise in the $\dot{V}_{O_2}$ data. Both these factors could have contributed to her results. These problems would be attenuated in the present study, however, because of the use of a longer measurement interval (1 minute). In fact, since a constant OP indicates a linear relationship between HR and $\dot{V}_{O_2}$, the little variability in OP for the "stimulus" data suggests that HR can be used to predict MR even in excited animals. Moreover, the lack of difference between OP in calm and aroused animals indicates that the same relationship can be used for all data which do not involve physical activity.

Figure 3 shows how this works with one of my subjects, Teen, using the subset of data from the Anova described above (n = 34). The regression (r^2 = 0.90) for the combined data when not walking was highly significant ($p < 0.0001$). Figure 4 compares the predicted and measured values of $\dot{V}_{O_2}$ when this equation is applied to all 364 data points recorded from Teen (excluding walking and first 2 minutes

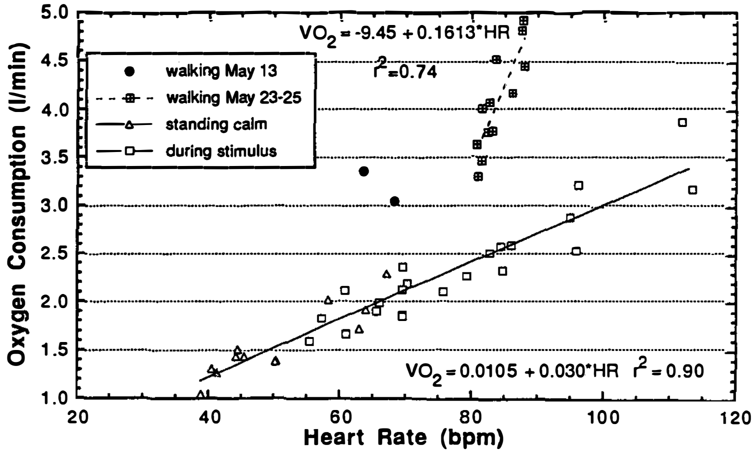

Figure 3. Relationship between oxygen consumption and heart rate for Teen. Regression for "walking" is based on data for May 23–25. Regression for "standing" is based on pooled data for standing calm and standing during stimulus.

following walking) between May 10 and June 8, 1989. HR was an effective index of $\dot{V}_{O_2}$, with errors of prediction ranging from -0.7 to 0.53 l O_2/min, mean = -0.04, SE = 0.01. Also of interest is the fact that, for this animal at least, arousal can incur considerable energetic cost (Figure 3). It remains to be seen if longer periods of stimulation could sustain such high levels of energy expenditure.

Figure 3 also shows a lot of variability in $\dot{V}_{O_2}$ and HR of walking on different days. More specifically, the relationship between $\dot{V}_{O_2}$ and HR for walking was very

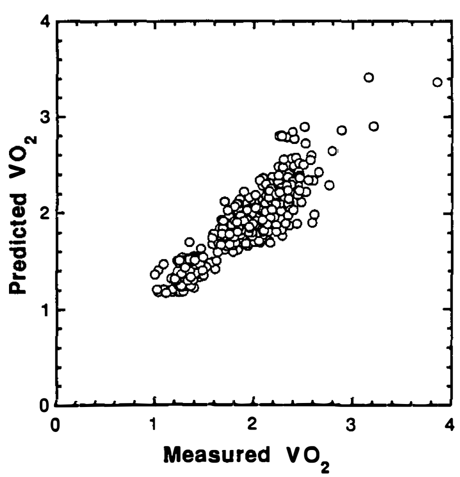

Figure 4. Comparison of predicted vs measured oxygen consumption when the regression established in Figure 3 is used with the complete data set for Teen (excluding data for walking and the first two minutes following walking).

different on May 13 then it was on May 23, 24 and 25, 1989. Similar shifts occur for most of the other subjects, sometimes from one day to the next. I am pursuing two approaches to handle this. The first is to divide the dataset for each animal into periods with similar values of OP for walking. This approach would be of limited value if free-ranging trials had to be analyzed because of the frequent calibrations needed.

I am also trying to determine how OP relates to other variables (temperature, wind, cloud cover, precipitations, fasting time, HR, number of days before or after paturition, an index of agitation and, for walking animals, speed, incline and time since beginning of walk). Results to date indicate that environmental variables had little or no effect on OP, but the other variable can have a significant relationship with OP, depending on the subject. For instance when Teen was walking, slope and speed both helped explain some of the variation in OP (OP = 0.0333 + 0.0087 × speed (in km/hr) + 0.009 × incline (in degrees), $r^2 = 0.77$). This should be intepreted very cautiously at this stage, because the small sample size does not allow me to dismiss "trial effects", or differences between trials which are due to factors not measured in this experiment. Certainly the good relationship between $\dot{V}_{O_2}$ and HR for the walking data of May 23, 24 and 24 (Figure 3), without including speed or incline, points in this direction. Possibly results for the other subjects will clarify this. This approach of trying to predict OP was unnecessary for Teen when standing (no variable correlated significantly with OP while standing, thus a regression based on OP [$\dot{V}_{O_2}$ = HR × 0.03022] yields essentially the same result as the regression based on HR in Figure 3). With some of my other subjects, these variables may allow me to extend the time period over which predictive equations can be used.

Conclusions

It is generally assumed that the relationship between energy expenditure and HR breaks down during arousal. The results presented here suggest that this might not be completely true. To be sure, the relationship found in exercising elk does not apply to the data collected when the animals were exposed to various stimuli. But, keeping in mind that I have demonstrated this for only one animal so far, it was possible to predict $\dot{V}_{O_2}$ from HR reasonably well even when the animal was subjected to arousing stimuli.

This is the first time that such a relationship is demonstrated for wildlife and, assuming that the trends showed here hold for my other subjects, it may lead to a technique which would allow us to determine the metabolic cost of disturbances, both naturally-occurring and man-made. Thus HR telemetry could be used both to assess which stimuli affect wildlife, and also the energetic cost of such disturbances, whether the animals respond behaviorally or not. This is especially important because my data showed that even when disturbance do not induce behavioral responses, they can result in relatively high energy expenditures.

More work is needed before this technique can be used on wildlife. These results need to be confirmed with more subjects and with other species. Some of the data most urgently needed include coverage of the remaining part of the annual cycle, the use of variable stimulus durations, and combinations of exercise and arousal.

Using HR telemetry to assess the energetic cost of disturbances does involve one additional difficulty over its use in assessing which stimuli do elicit arousal. In the latter, any wild individual can be instrumented and released. When estimates of energy expenditure are wanted, however, each animal must be calibrated at least once while exercising and when aroused. Because of the training involved, this will limit the study of disturbances to captive animals, a situation that is far from ideal considering that these can be habituated to some of the stimuli of interest. It remains possible that when our understanding of the effect of arousal on the energy expenditure of captive animals has improved, useful information can be collected from wild individuals.

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Special Session 5. *Streams: Ecosystem Linkages to a Healthy Environment*

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Cochair
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Opening Remarks

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This session was first envisioned by Joe Dillard at the April 1990 Northeast Fish and Wildlife Conference in Nashua, New Hampshire. Joe felt that a session on streams, encompassing the ideas of terrestrial habitat linkages, nonpoint pollution management, wetland maintenance and restoration, recreational greenways, as well as corridor and fishery management, would be timely.

Working on this session has been a great pleasure for me, since assisting Joe Dillard means simply staying out of his way, letting him do all the real work and me merely having to make a brief opening statement and moderate this session of excellent speakers who also worked diligently.

Joe and I both felt that this session ought to contain useful scientific information on biology, hydrology, stream morphology, ecosystem stress theory, etc., but should emphasize ''implementation'' of environmental protection and restoration techniques that are based on scientific information—Effective Implementation . . . capital ''E'' capital ''I''. . . . The speakers in this session will strive to teach you how to enlighten and empower people who are concerned about the environment, and align and focus their energies on understandable, doable and measurable actions that will protect or restore the environment and result in fulling the first part of this Conferences' theme—''Sustaining Conservation.'' Joe and I and the speakers at this session strongly believe that, by aligning and focusing people's concern and commitment to the environment on rivers, streams and their basin ecosystems, we ultimately will achieve the second part of this Conferences' theme—''An International Challenge.''

Papers given at this season will emphasize techniques for empowering grassroots laypeople to become more effective advocates and workers for sustainable ecosystem protection. Let me put the significance of this point in perspective. Environmental protection is being attempted at the highest level of central government. At the other end of the spectrum of environmental activism are millions of concerned individuals, each doing what he or she can locally to protect and enhance the environment. This is a process of "disjointed incrementalism," i.e., millions of uncoordinated actions collectively giving rise to a groundswell of enhancement to our environment.

By working with and capitalizing on the enormous amount of concern and commitment to be found at this grassroots end of the spectrum of environmental activism, this panel believes state fish and wildlife agencies can most effectively achieve maximum sustainable environmental protection for their efforts. The papers we selected for this season all provide information and/or instruction that will be useful to fish and wildlife agencies when developing partnerships with laypeople. The ideas and techniques discussed will help professional managers to "bridge the gap" between facts and expertise derived from rigorous scientific research and "implementation" of solutions to environmental problems, i.e., convert pure science into applied science.

This challenge of "bridging the gap" between scientific expertise regarding a problem and effectiveness in solving the problem has provided themes for past fisheries and wildlife conferences. I recall the September 1985 International Association of Fish and Wildlife Agencies' conference in Juneau, Alaska, at which keynote speaker Guy Martin chided professional fish and wildlife managers for their "slavish devotion" to strict scientific expertise at the expense of effective, aggressive, proactive environmental protection. Mr. Martin certainly was not advocating for lowering the high standards for scientific research and writing established by the American Fisheries and The Wildlife Societies. He was simply challenging professionals who have excelled academically and earned their degrees in rigorous science to then add some imagination and creativity in order to translate their scientific expertise into terms, concepts, metaphors and actions that grassroot activists can comprehend and accomplish. This is visionary leadership. At the plenary session of this Conference, one keynote speaker pointed out that "managers try to do things right (expertly) while leaders try to do the right things (effectively)."

Timing is everything. The rapidly spreading recognition of the notion that river and stream basins are logical, ecological subunits provides fish and wildlife agencies with a tremendous opportunity. Through creative leadership, agency heads can capture and coordinate the enormous amount of unfocused, latent environmental concern that exists at the grassroots level, channel it into action for sustainable conservation *and* broaden their agencies' constituancies. Experience shows that well designed river and stream protection programs assist laypeople to better understand ecology, relate to the land (maybe even develop a land ethic) and learn how to contribute to a sustainable global environment by acting locally and effectively. In addition to knowing their cultural addresses (street number and name, city or town, state and zip code), people should become familiar with their ecological addresses (sub-basin and stream, major basin and river, major drainage and estuary). They should understand the flow of water, sediments, nutrients, contaminants and energy, the flora and fauna, and the biological processes in their river sub-basin, basin and drainage ecosystem. From this will follow an understanding and appreciation of how their lifestyles and local land use patterns impact the basin ecosystems they live in, and more important, what actions they can take to protect and enhance them. They all tie together—a local trout stream today, major rivers and the oceans tomorrow. Ultimately, if every basin was ecologically sound, then the sum of these parts would equal sustained ''international conservation,'' the theme of this Conference.

I would like to give you a synopsis of a paper I wrote, entitled *Massachusetts Rivers: Environmental Designs for the Future*. The modus operandi that has evolved within the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement (DFWELE) as the main proactive fish and wildlife protection strategy is embodied in the Adopt-A-Stream, Save-Our-Streams, Aquatic Wild and other river corridor protection programs that you will learn about at this session.

The common vision that brings together environmental and often business interests is a vision of protected healthy riparian corridors that are teaming with flora and fauna. In addition to being worthy of protection in their own right, protected riparian corridors can serve as linkages that tie together nodes of existing protected habitat scattered throughout a given basin and thereby enhance their ecological values. The result is a minimum ''conservation safety net'' for biodiversity, clean water and opportunities for quiet sports within a given basin. This strategy of focusing habitat protection efforts on riparian corridors, the most critical ecological areas, i.e., the ''ecological infrastructure,'' of river basin ecosystems is a hybridization of the rapidly growing dicipline of landscape ecology. Landscape ecology is based on and serves as a metaphor for the myriad of sciences that underlie fish and wildlife management theory and practices. Landscape ecology teaches that living things need to move around, that species of fish and wildlife require a diversity of habitats, ecosystems and landscape types in order to complete their life cycles. Disjointed, small fish and wildlife preserves will not protect biodiversity and certainly not healthy populations of invertebrate species over the long run.

Massachusetts has over three quarters of a million acres of protected open spaces. However, it is severely fragmented. It exists as over 3,000 disconnected, oddly shaped parcels that range in size from a few acres to the largest of approximately 16,000 acres. Based on the tenets of landscape ecology, Massachusetts' existing open spaces must at a minimum be enlarged, rounded out and linked together if they are to provide adequate protection for healthy populations of diverse fish and wildlife species as development of surrounding private land continues throughout the state.

The Massachusetts DFWELE, through its Riverways and Adopt-A-Stream programs, works with local citizen/business coalitions to apply the tenets of landscape ecology to river basins. Emphasis is placed on protecting riparian corridors as the linkages. This strategy is not a panacea for biodiversity, but in the face of accelerating fragmentation and development of private lands, it is pragmatic and essentially administers CPR to existing preserves and basin ecosystems. What it lacks for a rigorous scientific basis, it more then compensates for by serving as an inspiring vision that is achievable. It also acts as a catalyst and provides a framework for additional environmental protection throughout a given basin.

The Massachusetts DFWELE has expedited river basin protection by aggressively installing and utilizing geographic information systems (GIS). Overlay maps produced by GIS serve as environmental spread sheets. They allow natural resources scientists to more quickly and accurately analyze the problems facing fish and wildlife populations and natural communities. Scientists can then formulate efficient solutions to those problems and further utilize the maps to convince grassroots activists of what actions are necessary to solve or avoid problems.

Geographic information systems overlay maps also serve as a common language.

Natural resources management professionals utilize the maps to more effectively communicate with, garner support from and provide direction to grassroots environmental activists, and convince elected policy makers of the need for site-specific and large-scale habitat protection.

The Massachusetts DFWELE is making measurable progress in protecting a conservation safety net for biodiversity throughout the Commonwealth. The Department works closely with existing watershed protection associations and instigates, where needed, additional Adopt-A-Stream groups. Geographic information systems maps have been very helpful in enlightening and empowering grassroots activists to affect conservation. To date, DFWELE has formed over 72 Adopt-A-Stream groups. This network of private environmental groups has contributed substantially to DFWELEs' ability to strategically acquire over 170 parcels of critical habitat. That equates to the protection of over 45 miles of major river corridor, 55 miles of stream corridor and the linking of hundreds of existing nodes of protected habitat.

Finally, in order to assure "sustained" conservation, the DFWELE is fast tracking (within budgetary constraints) the implementation of the excellent science/environmental education program "Aquatic Wild" in Massachusetts' schools.

Watershed Urbanization and Managing Stream Habitat for Fish

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Introduction

Biologists, planners, developers and the public are in a quandary. How can the demand for housing, development and a stable, healthy natural environment be met in the same area? There appears to be a rebirth of an environmental ethic driving the demand by society for this mix, exemplified by the United Nations report entitled, ''Our Common Future'' (W.C.E.D. 1987). In the report the term, ''environmentally sustainable economic development'' was adopted as a goal for the future. Yet how can these ethics be put into action where economic considerations or maintenance of high standards of living are fundamental driving forces?

It is not surprising that the demand for the best of both worlds appears to be strongest in urban and urbanizing areas. It is in the urban environment that the vast majority of people live and can witness the greatest losses of natural amenities. Streams and rivers are often the most highly visible examples of a degraded environment. In these flowing systems, the cumulative impact of discharges, channelization, dredging and flow disruption are readily apparent. Streams are the lowest point in the watershed of a system and tend to magnify the effects of landuse modifications and practices (Hynes 1975, Imhof et al. 1988). The fish community and its habitat are often the first to exhibit changes resulting from watershed landuse modifications and are obvious indicators and integrators of stream and watershed conditions (Klein 1979, Steedman and Regier 1987).

Our management of streams and rivers for fish and fish habitat has often been piecemeal in approach, focusing upon concerns at the waters edge or within small sections of the stream rather than attempting to manage the entire watershed of the river as a single ecological unit. As a result of this approach we have seen constant and consistent losses in stream quality and quantity, as well as ecosystem integrity in the face of landuse change. This change and loss has occurred as a continuum of modification from historically natural conditions through landuse changes such as deforestation, agricultural development and urbanization. This continuum is variable from watershed to watershed but the historical results have been the same: degradation in the quality, stability and diversity of streams and rivers and their related aquatic ecosystems.

The present way we perceive streams, rivers and watersheds is flawed. There are lessons to be learned from the past that would provide us with the tools to determine the causes and mechanisms of impairment of streams and the habitats for animals. There are ways to manage watersheds and streams for both people and the natural environment. This paper provides a brief overview of the mechanisms of degradation of streams and rivers, discusses some concepts that should be considered in the rehabilitation of urban and urbanizing streams and watersheds, and suggests a process that incorporates an ecosystems management approach on a watershed basis.

Urbanization Impacts on River Ecosystems

Urbanization as One Level in the Continuum of River Degradation

The modifications of rivers from pristine conditions to altered states has occurred over a millennium in Europe, whereas in North America, this change has occurred in the last 300 years. Many of the most significant changes to the quality of rivers and their catchments, both in Europe and North America, have occurred since the beginning of the industrial revolution (Mann 1989) with a marked acceleration since the two major World Wars (Backiel and Penczak 1989, Lelek 1989). Although North America has a shorter history of domination by Western civilization, the industriousness of our forbearers in modifying rivers and streams has made up for the lag.

This process of modification and degradation has been characterized as a continuum of change from pristine conditions to altered desirable states or oft times to states of extreme degradation (Steedman and Regier 1987, Steedman 1988, Regier et al. 1989). Research on these changes has indicated several major processes or mechanisms of modifications and degradation.

Removal of natural vegetation to accommodate urban and agricultural landuse triggers a series of changes that alter the fundamental character of the river including: modification of the hydrologic cycle; elevations of sediment discharge; channel modification; elevation of nutrient inputs; simplification of structural environment; and introduction of exotics. Urbanization further exacerbates these changes through constricting the floodplain of larger rivers, straightening and dredging for transportation, flow regulation by dams, water abstraction for mills, and discharge of human wastes. These processes act together to disconnect aquatic ecosystems from natural components of the terrestrial ecosystems (Naiman et al. 1988, Junk et al. 1989, Regier et al. 1989, Ward and Stanford 1989). Conventional forms of urbanization are often the endpoints in the structural degradation of rivers and their watersheds (Regier et al. 1989).

The process of modification and degradation of rivers in urban and urbanizing watersheds reduces physical complexity of the river channel and its floodplain thereby simplifying, modifying or eliminating physical habitat features required by fish and fish communities for various life stages (Imhof et al. 1991). In some situations, water quality degradation can also create physical barriers to animal movements up and down a river thereby isolating fish and other animals from portions of river systems that are necessary for various life history stages. This mechanism often occurs at a temporal and spatial scale.

A similar degradative ''syndrome'' appears to occur in many urban and urbanizing streams in North America (Klein 1979, Steedman 1987). The conventional urbanizing syndrome is characterized by reductions in tributary density, alteration or barriers to migration of fish and other animals, increases in frequency and magnitude of storm events and peak discharges. These modifications result in a concurrent reduction of baseflow, increased sediment loads, reduction in channel and floodplain complexity, and impaired water quality (Steedman 1987, 1988, Imhof et al. 1991).

Hydrologic and ecological pathways link rivers and their biota to their watersheds and downstream waterbodies (Figure 1) (Naiman et al. 1988, Ward and Stanford (1989). Modification of discharge patterns of a river through various processes including rerouting of water to other watersheds alters the river's physical characteristics. Modification of discharge within a watershed occurs through alteration of all major components of the hydrologic cycle including evapo-transpiration, throughflow, overland runoff and groundwater recharge. This in turn modifies the ecological pathways.

Evapo-transpiration, groundwater recharge and throughflow are often reduced through reduced watershed permeability and compaction of soils (Leopold 1968, Hammer 1972, Klein 1979). This modification of hydrologic pathways results in a net decrease in groundwater recharge and net increase in surficial runoff after every storm event.

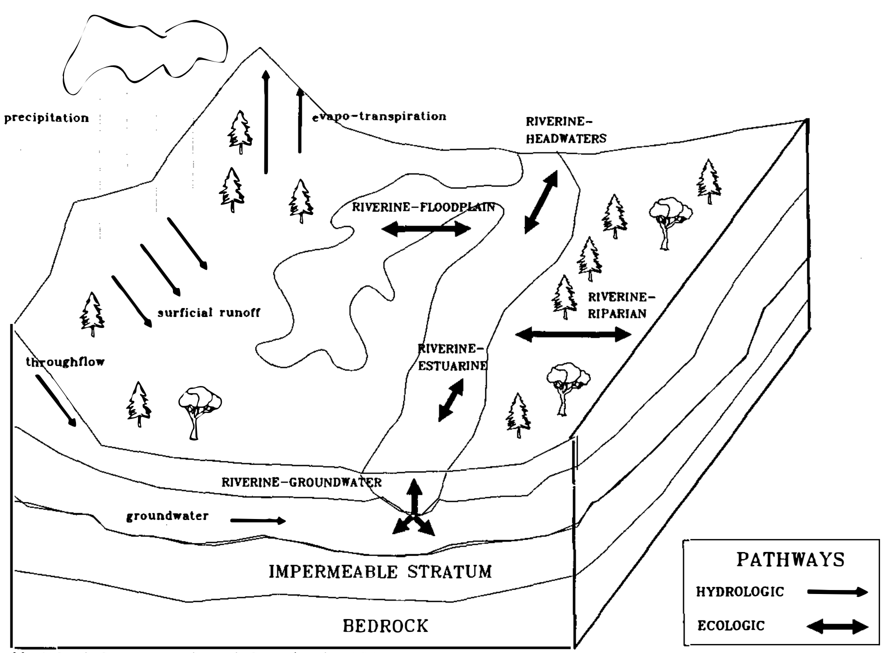


Figure 1. Hydrologic and ecologic pathways present within a watershed and floodplain.

Increased surficial runoff creates human and property hazards. It is therefore discharged in a safe manner fast enough to be eliminated before the next storm event.

The removal of this "stormwater" results in fundamental changes to the physical equilibrium of river channels (i.e., channel morphology) by altering the historical frequency and magnitude of storm events and increasing the discharge of sediments over ambient levels. This results in modification of channel width, depth, sinuosity, bedload transport, bed armouring, accretion of down-cutting, riffle:pool sequencing and connection to floodplain complexes. The net result of these modifications are structurally simplified river channels which lack the stability and physical diversity to support complex aquatic communities. This in turn degrades fish habitat by reducing access to spawning and nursery habitat or eliminating them entirely, eliminating temporal and spatial refuges (e.g., overwintering spring pools) and reducing the food supply of fish through reduction in the productivity of invertebrate populations (Imhof et al. 1991). This process in turn lead to degradation of water quality that can further affect fish production and survival (Holcik and Bastl 1976, Welcomme 1979, Halyk and Balon 1983).

The quantity of physical habitat available to fish is reduced temporally and spatially by urbanization of a watershed. In headwater portions of a watershed, tributary density is reduced through paving over, piping and draining as land is developed and serviced (Steedman 1987). This effect occurs predominantly in order 1–3 streams and results in a disruption of the riverine-headwater pathway. Since many headwater tributary streams are important to discharge stability of watersheds and are major spawning and nursery areas for many fish species, the loss of these systems has a major impact on species diversity, densities of individual species and ultimately on the productivity of the river. This process also has a major impact on fish predators as well as terrestrial and amphibian populations within the watershed (Imhof et al. 1991).

The interactions of the river and its floodplain are also severely impaired by urbanization. The biota of large rivers rely upon the interconnection of the river and its floodplain complex of pools, backbays, and wetlands during certain times of the year for spawning and rearing habitats (Welcomme 1979, 1985, Sedell and Frogatt 1984, Bacalbasa-Dobrovici 1989, Fremling et al. 1989, Lelek 1989). Fundamental reductions in productivity and species diversity result from losses or decoupling of the river-floodplain pathway (Halyk and Balon 1983, Welcomme 1985, 1988, Regier et al. 1989).

The reduction of groundwater recharge, resulting from modification of a watershed can also have profound affects upon the productivity of a river. Reduction of infiltration within a watershed often leads to reduction in recharge of shallow aquifers that control and moderate baseflows in adjacent streams. Although the repercussions of increasing surficial discharge are relatively well known, the impacts of reducing groundwater infiltration are less well understood. There is evidence that increasing surficial runoff within a watershed at the cost of reductions in infiltration has an affect on baseflow (Hammer 1973, Klein 1979, Steedman 1987). The implications of this are serious. Baseflow ultimately controls the maximum potential productivity of a river system through control of critical living space for aquatic animals.

Reductions of groundwater discharge into a stream also reduces water temperature moderation during critical periods of the year (i.e., late summer; mid-winter) and may have a major impact upon spawning and nursery habitat potential and thermal refuges (Benson 1953, Bilby 1984, Meisner et al. 1988, Meisner 1990a, 1990b).

Cunjak and Power (1986) determined that brook trout (*Salvelinus fontinalis*) require groundwater discharge areas for spawning and refuge habitat. Development of habitat modelling for fish production in southern Ontario indicates that groundwater discharge is the single most important predictor of trout biomass in streams (Bowlby and Roff 1986, Bowlby and Imhof 1989).

Information Needs and Linkages

To develop a comprehensive view of riverine ecosystems that will lay the foundation for management and rehabilitation, a number of key fields of ecological study are required. These fields include the study of the historical attributes of productive rivers, the study of river ecosystem theory and the study of ecosystem stress theory. These fields of study all contribute to the development of the science of restoration ecology (Cairns 1988, Jordon 1988).

Recent research using historical information on rivers has attempted to determine the physical and biological attributes of natural river systems and determine how these attributes operate systemically (Keller and Swanson 1979, Sedell and Luchessa 1982, Sedell and Froggatt 1984, Triska 1984, Lelek 1989). This information is essential in order to provide a baseline perspective of the type and variety of attributes these productive rivers and their watersheds contained historically. Historical information can provide a list and description of some of the attributes that should be built back into these systems in order to fully rehabilitate them.

Although understanding attributes of historically productive rivers is important, it must be set in the context ecosystem functioning. A variety of theories have been developed in the last 15 years to describe river biotic/abiotic processes. The River Continuum Concept (RCC) (Vannote et al. 1980, Cummins et al. 1984; Minshall et al. 1985, Sedell et al. 1989), the Serial Discontinuity Concept (SDC) (Ward and Stanford 1983, 1989), the concept of hydraulic stream ecology (Statzner et al. 1988), as well as development of watershed classification systems demonstrating the implicit linkages between geology and climate are being examined and developed (Platts 1979, Lotspeich 1980, Lotspeich and Platts 1982, Frissell et al. 1986). In all instances, river ecosystems are examined for the biophysical linkages that determine function and stability. Although there is divergence of opinion relating to the specific mechanisms of function and process between these approaches, there is a common theme that there are interactive biophysical pathways between the river and its watershed. It is possible that the hydrologic cycle and interactive pathways of a river channel and its terrestrial environment (Figure 1) could be used as the means to integrate biophysical processes within a watershed (Minshall et al. 1983b, Minshall 1988, Imhof et al. 1988, Sedell et al. 1989, Ward and Stanford 1989, Imhof et al. 1991).

Rivers and their aquatic communities pass through various states of ecological health as the characteristics of the watershed of the river are modified by man. Various authors have attempted to define the characteristics of ecosystem stress, the effects of stress on ecosystems and how these effects are manifest on the biotic community (Margalef 1968, 1975, Regier and Cowell 1972, Odum 1981, 1985, Rapport et al. 1985, Regier et al. 1989). This information is essential for river ecosystems rehabilitation.

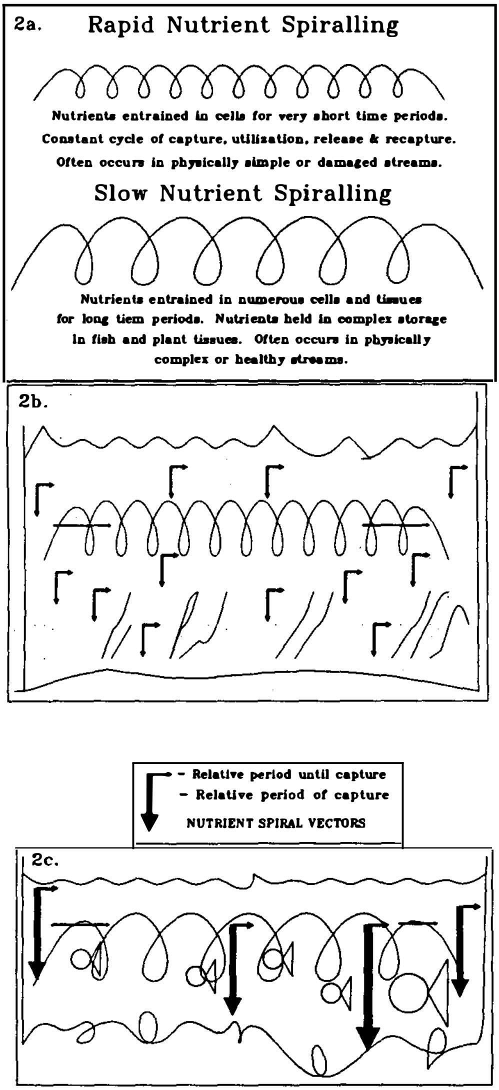
In modified river systems, the spatial and/or temporal loss of certain types of habitat or physical attributes can be more damaging to the biotic community than the loss of others. Rare or limiting habitats or attributes can be more damaging to the biotic community than the loss of others. Rare or limiting habitats or attributes act as loci of control and organization for various animals and often the entire biotic community. Steedman and Regier (1987) use the term "centres of ecological organization" to describe these habitat loci. Typical examples of these "centres" include reproduction and rearing areas, thermal refuge areas, and migratory staging areas. By their nature, these areas or centres are limited in space and time and are therefore extremely vulnerable to degradation and perturbation (Regier et al. 1989, Imhof et al. 1991). Steedman and Regier (1987) and Regier et al. (1989) further discuss the importance of centres of ecological organization as major attributes of river systems and their watersheds.

Floodplains that are inundated for at least one full month each year operate as centres of ecological organization. Severing of the river-floodplain pathway severely impairs the biophysical linkages of the aquatic environment and the terrestrial environment (Halyk and Balon 1983, Welcomme 1988, Regier et al. 1989, Bacalbasa-Dobrovici 1989). Severing often occurs actively (e.g., channelization, flow regulation by dams) and/or passively (e.g., head-cutting resulting from changes in the river's hydrology). Reconnection of the river-floodplain pathway should be an integral part of any river system management and rehabilitation program. In some instances, urbanization can play a role in assisting rather than exacerbating this process.

Development and urbanization simplify the structural diversity of rivers. The physical diversity and the biotic communities it sustains, from bacterium to fish, contribute to the river's ability to assimilate and process nutrients and other materials (Imhof et al. 1991). Therefore, rivers and their biotic communities exert a certain amount of "top down" control on water quality within the river as long as inputs from the terrestrial component of the watershed are not so concentrated as to have a toxic effect on the aquatic community.

In rivers, nutrients are constantly circulated from surface to substrate as the water flows downslope. Because rivers are shallow and well-mixed, nutrients are always available to the algae, bacteria, fungus, plants, invertebrates and fish of a stream. Nutrients that are in solution and suspension are rapidly captured by the biota of the stream and put into tissue production and storage. Depending upon the species capturing the nutrients, retention of a particular nutrient may be days, months or years. The term "nutrient spiralling" has been coined to describe the dynamic processing of nutrients in a river.

The concept and implications of nutrient spiralling have been discussed for many years in aquatic ecology (Newbold et al. 1981, 1982, Elwood et al. 1983) in the context of carbon or nutrient energy flow down a stream channel. Nutrient spiralling can also be conceptually used to illustrate and explain the temporal and spatial mechanisms of nutrient and carbon capture and entrainment in living tissues (Odum 1959, Imhof et al. 1991). Nutrient spiralling and entrainment varies from stream to stream based upon the relative physical and biotic complexity of the particular stream. Biotic complexity of a stream is usually linked to the stream's physical diversity and stability. Figure 2a is a depiction of the hypothetical difference in nutrient spiralling in simple (or damaged stream) versus stable complex streams (Imhof et al. 1991). Therefore, in theory, the more physically complex a river system, the greater its potential capacity to capture and entrain nutrients and ultimately maintain water quality and maximize aquatic productivity through long-term nutrient entrainment



From Imhof et al. 1991

Figure 2. Nutrient spiralling, entrainment and storage in streams (2a). Hypothetical nutrient spiral in simple and complex streams (2b). Tight spiral typical of simple or degraded streams composed of simple organisms that do not require complex habitat. Nutrients discharged into this type of stream are quickly captured and recycled by simple organisms such as algae and bacteria. Storage is brief and nutrients are constantly available for use by simple organisms (2c). Larger, more-open spiral typical of complex or natural streams containing a highly diverse physical character. Community composed of bacteria, algae, fungi, diatoms, plants, invertebrates and various fish species. Nutrients captured quickly and stored for days/months/years.

and storage (Figure 2b). The corollary is that the simpler the physical structure of the river, the less the retention time for nutrient storage and the poorer the water quality due to the rapid turn over from simple organisms (Figure 2c).

This hypothetical process may explain why many damaged and simplified streams exhibit relatively poor water quality, despite attempts to control point-sources of pollution. It implies that managers should protect and rehabilitate fish habitat in urban areas to help improve water quality.

The rehabilitation of these watersheds and their rivers therefore must be viewed also as a continuum and the solutions for this process must also be viewed as a continuum of actions designed to direct the biophysical mechanisms of the system to a desired state (Regier et al. 1989, Imhof et al. 1991). The return to historical conditions is not always possible. In many highly modified watersheds we must include a ''caveat'' which states that under highly modified situations, rehabilitation will mean ''making the stream inhabitable again,'' rather than returning it to its historically natural condition and productivity. Implicit in the concept of inhabitable are the qualifiers that the rehabilitated ecosystem be self-regulating and composed of animal and plant communities that are stable and self-sustaining. A rehabilitated river ecosystem may operate at a higher level of complexity and productivity than it did historically.

Management of Rivers

Most of western society resides near or beside rivers that have been affected by urbanization. Society is now beginning to question the logic and approach to environmental management and development. Development by many in modern society is now viewed as bad and this has fostered acceptance that all development causes environmental degradation. This view is not only held by concerned individuals but is shared by many environmental managers, biologists, politicians, engineers and developers. It is not surprising therefore that ''confrontational management'' rather than ''integrative management'' is the norm. Concerns of society have been reflected recently by the World Commission on Environment and Development (W.C.E.C. 1987).

In order to determine why rivers have reached such a state, despite modern attempts to manage and rehabilitate them in a more environmentally sensitive manner, the philosophy of environmental management as it applies to rivers must be examined.

River management and rehabilitation has operated within the anthropocentric context that rivers and other natural features must serve an absolute, direct human need in order to have value. Therefore, many rivers are viewed as sources of cheap energy, water supply, hydraulic waste, floodwater disposal and, at its worst, convenient conduits of human waste. Hydrologic modelling of the watershed in its existing state is often conducted to determine the engineering specifications for drainage, the ability of the channel to handle the ''waste water,'' and the implications on erosion and flooding. Once all these physical factors are satisfied, attempts are then made to accommodate the biological needs of the river. In this manner, planning and management allows for a simplistic drainage template to be overlayed upon the river and its watershed and then attempt to ''fit'' sound environmental management within this context. This approach is environmentally and economically unsustainable.

In many jurisdictions, including Ontario, Canada, most hydrologic engineering in urban watershed is done on the design storm basis using 1:2 year, 1:5 year, 1:25

year or 1:100 year recurring events for hyrologic and hydraulic modelling and design. Since rivers modify their channels during the annual storm which has an annual return rate of 1:1 to 1.5:1 (Leopold et al. 1964), this engineering approach causes fundamental changes to the river: its' morphology; recharge capability and ultimately the water quality, productivity and biodiversity. The assumption that the existing stream morphology and flow regime is the correct system is a tacit approval of the historical record of human pioneering, settlement and development which has resulted in these existing degraded conditions. The lack of fluvial geomorphological input in river channel management, despite the well-established science of the discipline is testimony to the unidirectional engineering view of rivers as simply conduits for waste water. This engineering has been challenged in Germany over the last several years and has resulted in a multi-million dollar program to "de-engineer" and re-naturalize their rivers (Arnold et al. 1989).

Most jurisdictions in North America have some form of environmental legislation and planning in place to minimize destruction or degradation of rivers. Ontario has one of the most complex and seemingly sophisticated systems of any jurisdiction.

Government initiated landuse proposals are subject to the Ontario Environmental Assessment Act which requires environmental assessment for any public undertaking. Depending upon the size, complexity or potential impact of an undertaking, each proposal is subject to some level of environmental scrutiny ranging from a full environmental assessment for high impact proposals (e.g., hydroelectric projects) down to relatively simple straightforward conditions of development (e.g., dock development). The requirements of the act can be applied to private sector undertakings, although this rarely occurs.

Privately initiated proposals are generally regulated under the provisions of the Ontario Planning Act. The Act regulates landuse planning in the Province and provides for the sub-division of land and development controls through a specific process of landuse designation, enforcement, modification and approval. The Act is implemented at the regional and municipal level. To ensure a sound consistent approach to land management at the municipal level, the Planning Act requires the development of Municipal Official Plans (OP). The OP is a strategic plan that establishes long-term landuse management goals and objectives for the municipality. It designates a present and proposed landuse designation on all lands in the municipality and ensures a consistent mechanism for amendments to the plan, development proposals, drainage and servicing studies, and plans for subdivision, etc. Although Provincial approval agencies (e.g., environmental agencies) may recommend modifications to the OP, the designation of land is driven by economic, development and political interests.

On a day-to-day basis within a municipality in Ontario, repercussions to the natural environment and the sustainability of terrestrial and aquatic resources are usually addressed by environmental agencies at the plan of sub-division level when detailed plans are submitted. At this point, the developer has already received approval in principle from various provincial, regional and local government agencies to develop the land and has invested substantial monies in the design and engineering of the undertaking. Comments by environmental managers and biologists on the need to modify design at this point are usually viewed with some hostility leading to confrontation. Environmental reviewers also have difficulty in determining or proving the cumulative impacts of a series of small developments on the physical, chemical and biological interactions within the watershed. This planning process leads to further degradation of the river. This situation has lead to the realization that protection and rehabilitation of rivers and their watersheds cannot be achieved at the plan-of-subdivision level. What is needed is a new process that manages the entire watershed of a river as an ecological unit in which the needs of natural components of the ecosystem are met or exceeded while at the same time accommodating reasonable human development and growth. Society is beginning to demand this approach.

There appear to be shifting views of environmental management. Norton (1989) suggests a shift in management views which began with an exploitist view of resource use to the development int he 1940–50s of two somewhat opposing views: preservationist/inherentist vs conservationist. He postulates the emergence of a new view which he terms "integrist." The integrist approach attempts to integrate the needs of humans into the requirements of healthy stable natural ecosystems. This approach attempts to restore and manage the physical, chemical and biological integrity of an ecosystem so that the ecosystem itself provides the necessary homeostasis to the system (Westman 1990, Imhof et al. 1991). The results of each of these views on river productivity is illustrated in Figure 3.

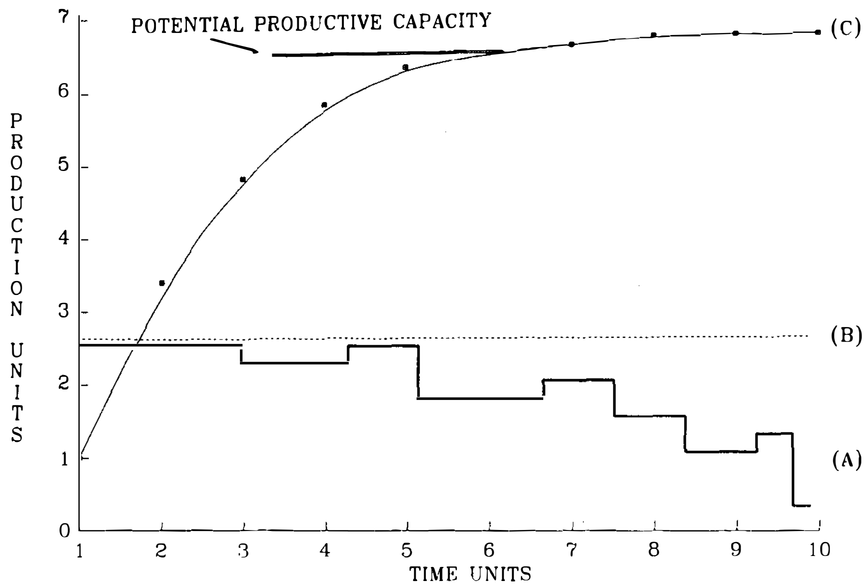
Ecosystem Approach and Watershed Planning

Components of an Ecosystem Approach

"Everything is connected to everything else" is an often used quote about the complex web of biophysical interactions of an ecosystem. There have been discussions on using an Ecosystem Approach to managing environments at various levels of resolution (I.J.C. 1978, Likens 1984). An Ecosystem Approach attempts to examine and identify the inter-relationships among biophysical, chemical and human elements of the ecological system. It recognizes the dynamic nature of the ecosystem, incorporates concepts of carrying capacity, resilience and sustainability. The approach strives to develop management targets based on the potential of the ecosystem in accordance with a balance between the needs of the natural system and human requirements. Although this concept has been proposed in the past, the difficulty has always been in determining how to apply the approach, how to integrate the disciplines that would examine the various components of the ecosystem and finally how to implement the approach through established approval systems.

An Ecosystem Approach requires a number of key elements: a logical geographic/ecological unit; an analytical process that allows for a view of the interactions between human and natural components of the ecosystem; and use of a physical pathway that interacts and integrates physical, chemical and biological processes. The approach must have the ability to develop targets, standards and guidelines for landuse management, development, protection and rehabilitation, and there must be a planning process used that merges the ecological targets and preferred ecological management scenarios into the municipal, regional and state/provincial planning processes.

We suggest that a process entitled, "Watershed Management Planning (WMP)" can be considered as one application of the Ecosystem Approach to management. In this process, a watershed is delineated as the geographical unit that encompasses a unique aquatic environment and its up-slope terrestrial environment. This then allows us to study the land:water interactions in a clearly defined geographic setting. In order to integrate and measure the physical processes that determine the charac-



From Imhof et al. 1991

Figure 3. Hypothetical response of production in rivers given various management views: exploitist management recognizes no "Y" axis—A; utilist view instantaneous production changes by examining potential impacts based upon the present productivity of the river, resulting in cumulative loss in production over time—B; preservationist views and strives for static productivity based upon the level of productivity at first examination—C; integrist attempts over time to strive for the potential productive capacity of the river.

teristics of the aquatic ecosystem and its terrestrial linkages, an integrative physical pathway must be used. For WMP's we are suggesting the use of the hydrologic cycle as the physical pathway in which water is managed, conserved and allocated based upon the requirements of natural environments and human needs. The use of the hydrologic cycle provides a clearly measurable pathway in which the characteristics of the land can be measured and the implications of water movement over and through the watershed can be analyzed for its implications on the biotic environment. This information can then be input into the river channel pathways that control aquatic productivity (Figure 1). The hydrologic cycle also allows for the development of targets for environmental and landuse management that are quantifiable.

In summary, Watershed Management Planning is a holistic, integrative approach to the management of land:water on a watershed basis. It strives to identify the functional attributes of each area of the watershed and recognize the interdependencies of components within the watershed and the need to determine optimal, feasible ecosystem targets within which the human social fabric is interwoven.

Watershed Management Planning

Watershed Management Planning may be a very powerful tool for integrating urbanization with the management and rehabilitation of rivers. By managing a watershed through ecosystem targets developed by the WMP, the physical attributes and essential land:water pathways are maintained and rehabilitated as urbanization occurs and the subsequent and ongoing integrity of the aquatic environment is ensured. "Fine-tuning" and tinkering with structural fish habitat can occur during approved developments or whenever time and money allows. The essential requirement is that all the biophysical processes of the river, its channel, floodplain and watershed be maintained and restored.

What size of watershed should be used? The management objectives of the WMP will likely determine the scale and resolution of the undertaking. One end of the scale could be an entire basin such as the Great Lakes including all tributaries, the five lake basins and the St. Lawrence River and its tributaries to its discharge point in the Gulf of St. Lawrence. The other end of the scale may only include one major tributary of a Great Lake or a sub-basin/tributary of a major river flowing into a Great Lake. Resolution will also vary with scale. The ecological targets set for the entire Great Lakes would be very general with very low resolution compared to the resolution required to determine how general ecological targets set in a larger scale WMP exercise are to be met on a sub-basin of a single major river.

If the objective of a WMP is to provide a process to develop ecological targets to manage and rehabilitate the environmental resources of a watershed, then from a planning perspective, large scale WMP's will examine the attributes of the watershed and its sub-basins at a relatively low level of resolution. This should be sufficient to set ecological targets for each sub-basin to ensure that they assist in achieving the ecological targets for the entire basin. The targets in an entire watershed may recommend values that in general would: optimize water storage in the aquifer systems; maintain or enhance baseflows; maintain or reduce peak discharges; maintain or restore stable, self-regulating channel forms; maintain or moderate water temperatures; maintain or re-establish diverse aquatic habitat characteristics, natural riparian features and attributes; maintain or re-establish corridor quality and connectivity; identify the relative allocation of water for the natural environmental and human populations. These targets reflect the thinking that water is a critical resource, not a waste product.

At a smaller scale, such as a sub-basin, the targets set for the entire watershed would be examined much more rigorously and at a higher level of resolution in order to determine how and where the targets could be met and to determine the various landuses, development designs and management practices that would be appropriate on each unit of land in order to achieve the targets. The key to this approach is the determination of opportunities to optimize components of natural environment, water resources (surficial and groundwater), and human development in a manner that ensures that rivers, fish habitat and water quality are maintained or enhanced as development proceeds. This approach changes the way we operate from having landuse/development objectives and targets drive environmental objectives and targets to the reverse.

The WMP approach has side benefits. To the municipality and development industry costs and confrontation resulting from a lengthy piecemeal review process can be minimized. Costs associated with servicing (e.g., maintenance, installation) can be reduced through cost effective application thereby minimizing redundancy and maximizing efficiency. These benefits will be greatest when the WMP is initiated long before pressures to develop become intense.

The WMP has drawbacks as well. It is biased toward aquatic systems based upon the use of the hydrologic cycle and does not clearly develop terrestrial linkages outside of the floodplain corridor of the watershed or outside of the watershed. Some consideration of upland terrestrial linkages must be incorporated into the planning design of a WMP in order to address this issue. The WMP addresses shallow aquifers and their links with surficial systems but is somewhat too narrow for the consideration of regional aquifers that transcend many watershed boundaries.

WMP's will require an interdisciplinary team made up of a variety of disciplines including and not limited to hydrogeology, hydrology, hydraulics, geomorphology, aquatic and terrestrial ecology, engineering, environmental and municipal planning, water quality and toxicology, and data management. Fundamental to the process will be the need to develop an interdisciplinary and data integration mechanism so that a conceptual model of the watershed or sub-basin can be developed, tested and used to develop and assess various target scenarios for the watershed.

To ensure the proposed WMP management scenarios are implemented, the WMP process must be integrated into the state or provincial planning process. In Ontario, planning legislation such as the Planning Act and the Official Planning (OP) process are two of the keys to implementing the ecological targets and management scenarios developed by the WMP process. The WMP process would complement the OP process by providing a scientific and objective process for the determining opportunities and constraints for the use of land in the watershed. Potential cumulative impacts on natural environments can be avoided, designed out of a project or at worst, mitigated by using WMP to set ecological goals, targets and landuse recommendations as the input into municipal planning. People can have their homes, their livelihood, healthy and clean rivers, and healthy fish communities.

In Ontario, examination of the various levels of scale and resolution are being employed in the development of various forms of watershed planning. At present, a number of watersheds ranging in size from 3–30 km^2 to 200–400 km^2 are being examined using various forms of Watershed Planning.

In the recent past several small-scale watershed studies with subsequent recommendations have been completed in Ontario. In all cases the plans met with enormous criticism by nearly all of the approval agencies (e.g., Wright 1983) or the public. Agencies often felt that the engineering was non-conventional, the open space green linkages were non-conventional, the infiltration techniques could not work and the biophysical rehabilitation was not possible, subsequently approval time was dramatically increased and profitability reduced. Environmental innovation should be rewarded, not penalized.

Summary

Rivers have been for many years used as sources of hydraulic power, irrigation, convenient conduits for waste water and human effluent, and transportation. Modification and deterioration of the aquatic environment, habitat and fish communities is not simply the result of development along a river but rather the cumulative changes of landuse within the watershed of the river. Conventional urbanization appears to be the endpoint in a continuum of change that began in most watersheds with the modification of land that resulted from the first human settlements.

Alteration and degradation of rivers has occurred through the modification of the hydrologic cycle of the river's watershed. Changes in the hydrologic character of a watershed acts to decouple the aquatic ecosystem from the terrestrial ecosystem by severing or impairing interactive biophysical pathways. To protect, manage and rehabilitate rivers and fish habitat in urbanizing watersheds requires a knowledge of the attributes of historically productive rivers, and understanding of river ecosystem theory and ecosystem stress theory.

The complexity of issues dealing with the surface waters within an urban area often overwhelms the planners, engineers, biologists and ultimately the decision-makers. Faced with a depressing array of seemingly contradictory goals such as flood protection, drainage, health, odour, safety, recreation, domestic water demands and natural environmental amenity, each discipline has responded by a simplification process.

By simplification within each discipline the overall problems become partitioned into a set of sub-issues which allow a feeling of satisfaction within each discipline or interest group. The results are that engineers channelize, naturalists protect specific sites, and developers develop uplands. This fragmented approach has resulted in conflicts that arise continuously resulting in great environmental, economic and societal costs.

Historically, biologists and naturalists acting within the planning and policy framework have focused upon the relatively small minor sites within a watershed that contain wetland or forested subsystems. While each of these areas may be important, they may have varying degrees of importance to the overall watershed ecosystem. Unfortunately the strong focus towards these sites, has deflected attention from ecosystem components which may be critical to the sustainability of the total system. These critical areas include recharge areas or areas which should be reinstated as biotic corridors coupling the terrestrial and aquatic systems.

An ecosystem approach using the watershed as the logical geographical/ecological planning unit is recommended. By managing water as the integrator of biophysical processes within a watershed, ecosystem targets can be developed to balance the requirements for healthy, stable and productive rivers and terrestrial environments while still meeting human needs.

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Economic Values in Management of Natural Streams in Missouri

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Introduction

Resource managers and biologists are continually confronted with the ever present, ever growing challenges of human management, now referred to as human dimensions in resource management. Among the most challenging tasks confronting managers is estimating economic benefits of fish and wildlife management. The idea still holds much novelty, illustrated by the story of the biologist conducting a survey of deer hunting values. After several days at a check station, asking deer hunters to value their day of hunting and weary of hearing hunters saying, "You can't put a value on deer hunting," the biologist assumed deer hunting must be "worthless!"

This is exactly the conclusion drawn by many decision makers. Facing well-intended statements by resource managers and recreationists that fish and wildlife resources are "priceless," the decision maker can easily transmogrify this response to "worthless." Our refusal to estimate values of fish, forest and wildlife resources, and make those values comparable to all other values in society (i.e., dollars and cents), places the very resources about which we are so concerned at terrible disadvantage when stacked against goods and services with market prices.

The aim of this paper is twofold: (1) to strongly encourage greater admission of economics into fish and wildlife management and the resource allocation process; and (2) to present a few economic values from recreational use studies of Missouri streams, and discuss the implications of these results for stream conservation.

Values of natural streams to Americans have been rising in recent years. Evidence of this includes the Clean Water Act and the Wild and Scenic Rivers Act, increases in conservation revenue-raising taxes such as federal taxes on water recreation equipment, and growing political forces in the form of workshops, symposia, conferences, publications and lobby interests dedicated to natural stream conservation and preservation.

Decisions regarding development and use of stream resources require policymakers to compare advantage to the public. Such determinations are difficult because they involve competing and often conflicting stream values and uses. Since stream degradation results from an unwillingness and/or inability to put dollar values on environmental costs and benefits, most decisions made seldom lead to an efficient allocation of stream resources. Although multiple uses may be encouraged, it is more typical that one use conflicts with another. This problem suggests two primary tasks: (1) to identify the total economic values of stream resources; and (2) to capture and present those economic values in a way that influences resource decisions (Salwasser et al. 1984).

Economics in Stream Resource Management

Because all natural resources are limited, their use and the services they provide require people to make endless choices among alternatives. These alternatives are weighed in two questions (Sinden and Worrell 1979). Is it worthwhile to obtain a thing or carry out an action? And is it better to select one option instead of other possible alternatives? Both questions involve a concept of value. Value is used as a measure or indicator of relative importance, and the comparative values of alternative things or actions are decision guides in the allocation of scarce resources.

Values have been classified as either instrumental or intrinsic (Callicott 1986). Instrumental value is the utility of something as means to some end, while the intrinsic value of something is its inherent worth as an end in itself. The value of a thing depends partly on the circumstances under which it is evaluated (Sinden and Worrell 1979). Value is not a fixed, inherent property, but a variable property whose magnitude depends not only on the nature of the thing itself but also on the perception of those who evaluate it and the environment in which it is assessed.

A value system, put simply, is the complex set of criteria an individual uses to choose among several mutually exclusive actions he/she will undertake (Arrow 1967, Bryan 1980). In a social context, it is "a moral demand system." In an economic context, a value system describes a set of rules governing choices for many or all possible environments.

Value, in the objective realm, is the expressed relative importance of worth of an object to an individual or group (Brown 1984). Value in this sense is a preference for one thing or state over another. Worth is not a character of the object, but rather the standing of the object relative to other objects. The preference relationship between a person and an object results in different objects being of different worth (Sinden and Worrell 1979).

Economic measures of value belong to the class of preference values known as assigned values (Brown 1984). Prices and other monetary measures are assigned value descriptions. Monetary prices are gradings against a pre-established standard ranking such as dollars. From the social perspective, monetary values are based on a branch of economics called welfare economics (Bishop 1987). Welfare economics seeks to define the optimum state of society, known as the "Pareto Criterion," where society is better off if, and only if, all members of society believe they are better off, or at least not worse off.

Unfortunately, this Pareto Criterion is scarcely ever met. Thus, to make welfare economics practical for decision making, a compensation test has been introduced (Bishop 1987). The compensation test indicates that a program will increase social welfare if those who gain from the program can compensate the losers fully and still be better off themselves. The compensation test provides motivation for introducing economic values to resource use decisions. It provides a common framework for measuring benefits to the gainers and costs to the losers. This is usually an assigned value system known as benefit-cost analysis.

Economic values are a small subset of preference values in which price represents a common denominator most frequently used in welfare decisions. Therefore, economics makes a substantial contribution to resource allocation and mitigation strategies. It is important from the standpoint of social welfare decisions to know who bears the costs of resource alteration and depletion, and who benefits from environmental enhancements (Brewer 1971). Economic information is needed to identify and compare alternative costs and benefits of resource development and management, such as flood control versus natural stream fisheries.

Stream Resource Values

Natural stream values fall into two broad categories of resource values: *biological existence values* and *economic resource values* (Salwasser et al. 1984). Biological existence values derive from religious and ethical beliefs; thus, dollars are not an appropriate measure for these values. Economic resource values include commercial exploitation, the economic value of pursuit for ownership (harvest-based recreation), the economic value of pursuit for observation (non-harvest recreation) and the economic value of knowing the resource exists (preservation). Monetary worth can be and is assigned to economic resource values.

The difficulty in measuring these values stems from the property rights system developed in the United States regarding renewable natural resources. Property is really a set of rights to the use of an object (Jackson 1980). Natural streams in the U.S. are for the most part entrusted to government to manage for the public good. Thus, stream resources are referred to as ''public trust'' resources, and as so, are not normally bought and sold in the marketplace. Measuring the economic value of stream resources is not a straightforward process and requires systems for measuring values outside the normal market system.

In the context of ''public trust'' values, there are two economic values categories: *use value* and *preservation value*. Total economic stream value has five components: (1) commercial use of the stream; (2) on site recreation use of the stream; (3) an option demand to maintain the potential to use the stream in the future; (4) an existence value derived from simply knowing the stream exists in a preserved state; and (5) a bequest value derived by individuals from knowing that future generations will be able to enjoy the existence or use of the stream (Loomis 1989).

Natural streams are a primary source of water for many different needs and demands. Water is one of the most important natural resources necessary to insure human survival (Gibbons 1986). Water is treated as a free resource, with no charge imposed for withdrawing water from surface or ground sources, and seldom is there a charge reflecting the opportunity costs of putting water to one use at the expense of another.

The marketplace is not used to balance water supply and demand or to allocate water supplies for several reasons (Gibbons 1986). For one thing, water is naively perceived as too vital and elemental a commodity to be left to the economic forces of self-interest and profit-maximization. Also, water is a fugitive, reusable, randomly supplied resource with characteristics similar to that of a common property resource. In other words, sometimes wrong decisions are made, and economics can help to improve decision making.

Methods of valuing water resource benefits depend on the water use classification scheme employed. Water use has a number of dimensions—namely quantity, quality, timing and location (Gibbons 1986). Since water is bulky in relation to value, transportation of water is expensive and location of supplies is crucial. Water quantity is a complex dimension in that water is not necessarily consumed while being used and can be in whole or part re-used. Water quality factors are important since different uses require different water quality and affect water quality differently. And one water use may impact other uses, creating additional costs for that use.

Economic Value of Natural Streams

A basic classification of water is by location (Gibbons 1986). Uses occurring in the watercourse and dependent on its flow characteristics are called instream uses and include navigation, hydroelectric power generation, waste dilution and recreation. The offstream sectors are municipalities, agriculture and industry. In economic terms, water use can also be classified as an intermediate or a final good. Water can be used in the production of another good or service, such as the irrigation of crops, as an intermediate service, or used by the final consumer for recreation activities. The consumer's water uses provide personal satisfaction or utility directly, while the producer's water uses have value derived from the ultimate value of the resultant good or service. Natural streams provide for all instream and offstream uses, so that the value of these water uses is a measure of the value of the stream resource. Missouri stream recreation values are emphasized here and briefly compared with other stream values.

Demand for water-based recreation has been increasing as population expands and the desire for outdoor recreation grows, particularly near urban areas (Gibbons 1986). Increasing environmental awareness has resulted in higher nonuser values for environmental assets. Legislation to protect natural streams from further development indicates a high preservation value associated with these resources.

When recreationists are charged a market price for the opportunity to engage in water-based recreation, the minimum value can be equated to price. This is the case with privately owned recreation facilities, where the producers' willingness to sell recreation opportunities equals the recreationists' willingness to pay for recreation experiences. For most publicly provided recreation opportunities, values must be estimated using nonmarket methods.

Few recreation economic analyses focus on the value of the water resource, and fewer still provide marginal, unit water values. However, in the context of natural stream values, it is the riparian ''package'' which makes up the recreational experience or preserved resource. The value of recreation is a combination of stream flow, habitat, animals, location, physical features and other variables. Thus, estimates of site value, activity value or preservation value provide an estimate of natural stream values in the allocation of competing stream uses.

One of the most direct measurements of recreation worth has been the estimation of recreationists' spending. Expenditure estimation assumes the value of recreation is at least equal to all recreation-related expenditures made by resource users (Sorg and Loomis 1985). Expenditure measures are often used by public agencies to substantiate budget requests, and they can be instrumental in persuading local groups of the economic benefits of recreation that result from increased tax rolls, greater local revenue generation and creation of jobs (Gilbert and Nobe 1969). Spending also has a general propaganda value in dramatizing natural resource values.

Sizable recreationist expenditures are generally not exaggerations. In the U.S. in 1985, stream anglers spent over $8 billion for fishing trips and equipment (USFWS 1988). In Missouri, stream anglers spent over $400 million for fishing recreation (USFWS 1989). This magnitude of spending has many positive impacts on local and state economies. Dollars spent by recreationists are re-spent several times, generating additional business and supporting many jobs; stream angler spending alone supports over 10,000 jobs in Missouri.[1]

Outdoor recreationists' spending generates tax revenue for Missouri. In 1985, state sales tax revenue from stream angler spending was about $16 million, which equals one-third of the Department of Conservation (MDC) annual sales tax revenue generated from the one-eighth percent sales tax for conservation! Additional tax revenue is derived from income taxes on jobs supported by recreational expenditures. These dollars support many conservation programs such as the MDC's Streams for the Future. Millions of dollars are also spent in aesthetic-oriented stream activities for cameras, canoes, binoculars, special gear and clothing, and travel-related goods and services.

Specific studies of recreationists' spending patterns have been conducted in Missouri. These include waterfowl hunters at two wildlife areas and Missouri River recreation. Missouri River recreationists spend about $10 million annually, generating $20 million in total business (Weithman and Fleener 1986). This spending supports about 400 jobs and generates more than a half million dollars in tax revenue. Surveys of the upper Mississippi River basin between 1972 and 1981 estimated annual river recreation spending at nearly $0.5 billion, with sport fishing accounting for $125 million (UMRCC 1982). Mississippi River waterfowl hunters spent $17 per day along the river, accounting for over $5 million spent annually. One group of Missouri duck hunters spent over $1,300 annually per hunter on hunting equipment and travel (Missouri Department of Conservation 1988b).

Expenditure data are often incorrectly used to value recreation resources and activities. Total value of the resource *is not* equal to the amount spent on related goods and services. If this was true, resources would be worth the chargeable costs, such as extraction and shipping, of putting them on the market. Total willingness to pay, or total net benefit of recreation, is the sum of the cost of procuring the recreation experience, dollars spent on equipment and travel, and satisfaction received by an individual from the experience, the consumer's surplus (Filion et al. 1985). Expenditures do not measure consumer's surplus value; but reflect only the provision of facilities, goods and services.

One technique for measuring this value is the *Travel Cost Method*, which estimates the demand for a recreation site by assuming that the price of consuming recreation at that site varies directly with the distance the consumer is from the site (Sorg and Loomis 1985). Consumption varies directly with changes in travel cost, which is used as a proxy for price in deriving site demand. The demand curve is used to estimate the consumer surplus value of the recreation site and its associated resources, and is the value over and above all expenditures recreation-related equipment and travel.

Travel Cost has been employed in several recreational use studies conducted in the past 5 years in Missouri to estimate outdoor recreation benefits of managed areas and streams because of the ease with which methodologies can be integrated into other recreational use surveys (*see* Missouri Department of Conservation 1987, 1988a).

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[1]Estimates of employment, business activity, and tax revenue are based on a Missouri state input-output model developed by Harmston (1967) and modified by Missouri Departments of Natural Resources (1988) and Conservation (1988b).

Per trip values ranged from $4.50 on the Missouri River to $16 per recreation trip at a Mississippi River wetlands management area for several recreation activities (Table 1). Per trip values translate into area specific annual benefits when combined with recreational use estimates. Although per trip values were low in some instances, a majority of recreationists lived near recreation sites and took numerous trips, such that total annual benefits exceeded annual costs on areas for which management costs were available (Missouri Department of Conservation 1989, 1990).

When recreationists were grouped by use type, per trip values ranged from a low of about $2 for anglers on the Missouri River to a high of $33 for waterfowl hunters at a Mississippi River wetland area (Figure 1) (Missouri Department of Conservation 1987, 1988a, 1988b, 1989, 1990). Although fishing was a major Missouri River use, non-harvest activities like sightseeing and boating comprised the bulk of annual recreation. Values for one segment of the river were fairly similar, but it's interesting to note that aesthetic type activities were more highly valued than angling activities. When expanding values to total river use, annual recreation benefits were nearly $3 million, with aesthetic activities comprising the bulk of these benefits due the much larger number of trips taken. A 1989 study of Gasconade River recreation included recreational use estimates of angling, boating and many non-harvest activities. Although campers spent the most time on the river, value per trip was highest for boating.

This review has emphasized the recreational use of streams for two reasons. One, the values of various stream uses are not very comparable. Attempts have been made to make them comparable by use of a common denominator, such as *dollars per acre-foot*, but such information is not always available, and still leaves the second problem, that of highly variable estimates of stream values. A graphical summary in Figure 2 of stream value estimates points out the confusion and inconsistencies that exist in water resource valuation. By taking the lowest estimate and highest estimate from several different studies (Gibbons 1986), it's easy to see that value

Table 1. Travel cost consumer surplus site values for Missouri streams, wildlife management areas and a reservoir. Trips are day trips to each site for the survey year with 1990 constant dollars shown for comparison.

Recreation site	Survey year	Annual trips	Trip value ($ per day)	Annual $ value	CPI[a]	1990 Trip value ($ per day)
Lake Taneycomo	1979	329,000	8.80	2,900,000	1.85	16.24
Dear Ridge Wildlife Area	1984	14,588	9.90	144,400	1.29	12.77
Whetstone Creek Wildlife Area	1988	15,188	10.26	155,800	1.13	11.62
Ted Shanks Wildlife Area	1988	32,657	16.19	528,700	1.13	18.34
Missouri River	1984	670,000	4.50	3,015,000	1.29	5.80
Gasconade River	1989	457,000[b]	5.80	2,650,000	1.08	6.27

[a]Consumer Price Index, U.S. city average all items, 1990.
[b]Annual trips are based on 1977–79 survey of entire river over 12-month period. 1989 survey indicated no significant change in total trips.

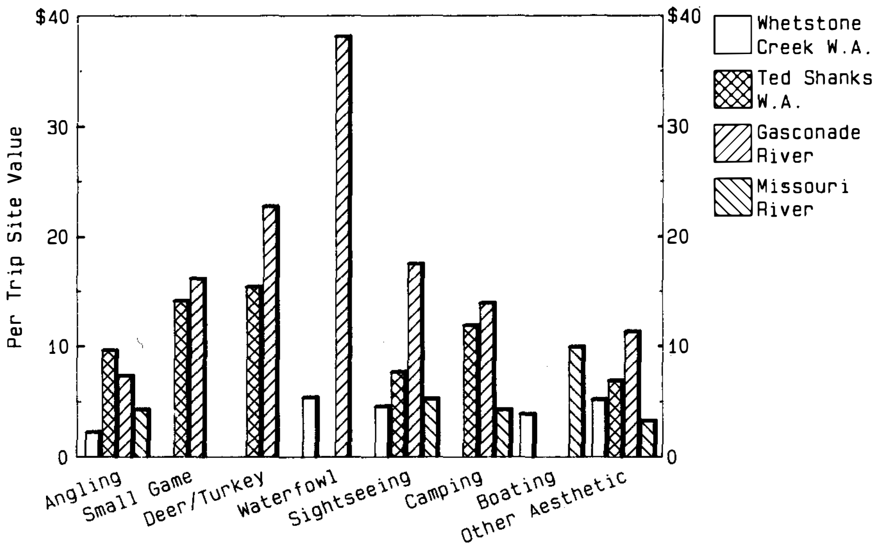

Figure 1. Per day trip travel cost consumer surplus values by recreation type for Missouri Department of Conservation wildlife management areas and Missouri rivers. Values are in 1990 constant dollars.

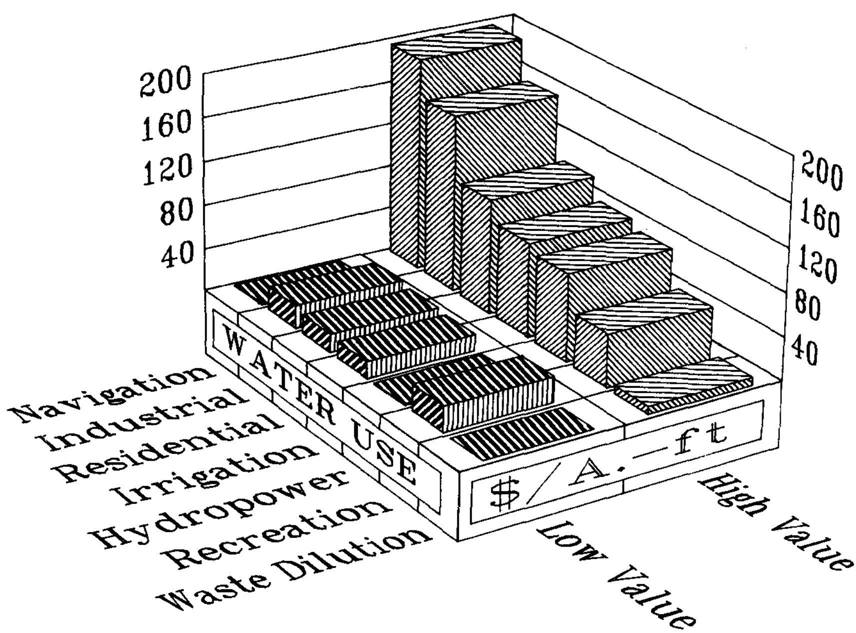

Figure 2. Different nonmarket valuation methodologies result in inconsistent and variable dollar value estimates. Values are in constant 1980 dollars and may be average or marginal values (from Gibbons 1986).

comparisons across studies, geographic locations, and time quickly lose significance. Still, recreational use values are on a par with other stream uses.

Attention has been directed to recreation and preservation values because of the need to insure that such values are estimated *and* are included in decisions of natural stream use and development. Other stream values are easily inserted into benefit-cost analyses because of their supposed, obvious economic worth. However, it would appear that the value of most stream uses is not easily estimated nor readily comparable. Thus, there is a need in all economic assessments to use a common denominator from the start for estimating these values, and recreation values are no exception. Such assessments also must include the negative impacts or costs associated with certain stream uses such as stream bank erosion, alteration and loss of fish and wildlife habitat, changes to water quality, and even changes to stream flow.

Consider navigation and recreation on the Missouri River. The 1980 annual navigation value of the Missouri was estimated at $3.2 million (Gibbons 1986). The 1985 recreation value of the Missouri was about $3 million (Weithman and Fleener 1986). Recreation use value per surface acre was $23, while 1980 navigation value was less than $1 per acre (Gibbons 1986). Although navigation value was for the entire river, the recreation estimate was *only* for that portion of the river in the state of Missouri. And recreationists pump far more dollars into state and local economies than a few commercial barge operations. The significance of economic values of recreation is illustrated by the benefit-cost (B/C) ratios for alternative wetland uses. The B/C ratio for recreation at a Mississippi River wetland area was 2.15 to 1, while the B/C ratio for crop production on the same area was only 1.23 to 1 (Missouri Department of Conservation 1990).

Implications and Conclusions

As important as economic value estimates are, it is equally important to apply recreational and preservation values of streams to resource use planning and decision-making. Recreational and preservation values encompass aesthetics, stream biology and ecology, science and education, and social welfare. The need to provide economic measures of these stream values is paramount to preserving stream resources through the democratic process and economic market mechanism.

A change in the priority ordering of fish and wildlife management goals appears warranted. If economic values of renewable natural resources must be included in stream use decisions, socioeconomic research must be conducted. Indeed, resource managers and administrators continue to require estimates of particular fish-, forest- or wildlife-associated values, and yet, the best estimates generally are limited ones. For the most part, those asking for economic information either have no influence on goal priorities or are decision makers who, for one reason or another, just can't seem to move this need up the priority ladder, but continue to favor basic biological and ecological research over socioeconomic investigations. In most instances, economic valuation of our stream resources, rather than one more food habits study, will be the key to preservation and conservation of these resources in the materially motivated society in which we live.

The role of economic valuation in resource conservation has been recognized in Missouri. The MDC has long conducted recreational use surveys of streams (e.g., Fleener 1988) and continues its commitment to recreational use surveys. The MDC employs a bioeconomist and social research analysts. Studies of public use and economic value continue today and more studies are in the planning stage, including a statewide river basin creel survey to include economic analyses. The information from these studies is used in resource planning and management. However, because natural stream resources are often undervalued or not valued at all in relation to other stream resources and uses, economics and values now warrant equal standing with population dynamics, reproductive biology and habitat management. Natural stream conservation depends on the biological commitment, but efficient conservation decisions depend on a commitment to the decision economics of our free-market enterprise system.

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Streams for the Future: Missouri's Expanded Program of Stream Improvement

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Missouri is truly a river and stream state, with more than 56,000 miles of warmwater and coldwater streams, big rivers, spring branches, prairie sloughs and mountain freshets. Our state's rivers sustained the red man, harbored settlers, and provided navigation and power for a fledgling nation. Rivers have made Missouri a leading agricultural and industrial region at the crossroads of the continent's great rivers—the Mississippi, the Ohio and the Missouri. Rivers are solidly integrated in our state's tradition, heritage and psyche.

However, nearly a century of abuse and neglect through channelization, pollution, impoundment and diversion has put these great resources at risk for sustaining natural values such as water quality, fish, wildlife and recreation. During the first three quarters of this century, Missouri saw no need to develop protective water law. Rather, water has been viewed historically as a common enemy. The last decade, however, has seen a reversal of this public mindset as more and more of our flowing water resources were lost or degraded. Now water quality improvement is a high priority public goal and the production and restoration of natural riverine values is very much a public issue. The evolution of viewing water and rivers as well within the public trust has been initiated.

The Missouri Department of Conservation is steered by a four-member commission. Their response to this growing public concern came about in August, 1989 when they approved a broad new program called "Streams for the Future." As the name implies, this was viewed as a first step in an effort that would be long and difficult. The commission was aware that fundamental changes in land-use philosophy, management techniques, public awareness and legislation would be needed. The cornerstones of this evolutionary process would be education, involvement, improvement and partnership.

The perspective of the Department's staff instrumental in developing this program is important to understanding the timing and construction of the program's key elements. The Department is an agency charged with biological matters, but the physical world clearly affects both resources. Though the Department's professionals are traditionally fish and wildlife biologists and foresters, we knew that this new program would rely heavily on watershed science, hydrology, fuvial geomorphology, open channel hydraulics, engineering and social services. We realized that rivers are complex, physically, biologically, chemically and emotionally. We further realized that all these factors and disciplines would have to be considered and incorporated into the program. Streams for the Future approaches river conservation from this broadened standpoint.

Planning began in earnest in the early 1980s as conditions indicated that the opportunity to seriously consider a new river conservation initiative was at hand. The Federal Soil and Water Conservation Act of 1977 (PL95–192) directed the U.S. Department of Agriculture, Soil Conservation Services (SCS) to make an assessment of our nation's soil and water conservation needs on five-year intervals.

The first assessment, published in 1982, showed that Missouri was second in the nation in soil erosion losses. This fact galvanized our state's conservationists to action. Voters approved an initiative petition to tax themselves one tenth of one percent to place more conservation practices back on the land.

During this same period, the federal agencies involved with land and water development projects were charged to consider non-structural as well as structural measures. Early coordination with the SCS in Missouri showed great promise for non-structural river corridor enhancement measures in their small watershed (PL83–566) program. Congress was seriously considering, and ultimately approved amendments to the Dingell-Johnson excise tax formula. These amendments, advocated by Congressmen Wallop and Breaux, ultimately led to the increased financing necessary to developing a new stream management program. Finally, Department studies had shown the extent of river damage caused by activities such as channelization, riparian clearing, sand and gravel dredging, reservoir construction, road and bridge problems, recreational misuse, and many other factors. From a planning perspective, the problems and needs were clearly visible.

With this brief perspective behind us, let me now explain the rationale and composition of our program.

One fact of life the Missouri Conservation Department has learned during its 50-year history is that programs do not succeed unless supported by the people. The foremost goal of Streams for the Future, therefore, is to involve people in stream conservation, as well as build an active constituency for stream health. Surveys of public opinion and knowledge have shown Missouri citizens deeply concerned for river conditions. Knowledge of the real problems and solutions, however, was lacking. Clearly a major educational undertaking was needed. This need will be addressed by a long-term effort to provide continuing information through traditional avenues such as movies, videos, brochures, articles, radio and television appearances and the like. However, new and innovative avenues are also clearly needed. For starters, we are developing a computerized interactive video on stream ecology, cause and effect relationships, problems and solutions. This experimental effort will be installed in the state's nature centers, the St. Louis Zoo and similar areas. The search for other needed educational venues has only just begun and will be broad in scope.

The need for educating the concerned public is being addressed through a new program which directly involves people in stream conservation affairs. The program called Missouri STREAM TEAM is co-sponsored by the Missouri Conservation Federation, an affiliate of the National Wildlife Federation and the Department.

The concept for this effort came from recommendations of more than 600 citizens in a giant town forum in 1988. The people indicated they wanted to provide a service to the resource and that they wanted to learn more about river problems and needs. They also wanted to be able to provide informed opinions on river conservation issues.

Thus, Missouri STREAM TEAM has three goals—education, stewardship and advocacy. Membership is open without charge to any person or group wishing to find a way to contribute to the cause. The Conservation Federation provides policy guidance through a citizen committee; the Department provides technical assistance and a coordinator position.

To date, more than 210 groups have registered. Approximately half of these 7,000 people are urban dwellers and half are rural. Many are stream landowners. Team members come from schools, corporations, sportsmen's clubs, families, youth groups and civic organizations.

Groups are encouraged to "adopt" a stream of interest or convenience and conduct a layman's environmental assessment which is called a STREAM TEAM inventory. Analysis of the inventory reveals the range of problems impacting their stream segment. Setting goals for achieving some solutions to a selected problem is the next step. A wide variety of activities has now been spawned ranging from litter control to water quality monitoring and greenway developments.

Through these civic-minded, informed and proactive citizens, the Department hopes to achieve an empowered constituency that will provide the interest in further developments in river conservation. The Department is placing equal emphasis on the needs of Missouri's river landowners. Approximately 93 percent of the riparian lands in Missouri are in private ownership. In addition, most stream problems are found on private lands. Therefore, any stream improvement program must involve landowners.

Effectively working with landowners can be a problem. Working on stream problems on private land can be a bigger problem; however, we felt that working through the ongoing state and federal programs to improve the soil conservation conditions in our state's watersheds was a direct "pipeline." Surveys conducted during the planning for Streams for the Future showed that landowners were willing to learn about and implement cost effective and environmentally acceptable techniques for solving stream problems.

Our philosophy going into this program has been to divert landowners away from the "bulldozer mentality" of the past and toward an approach that works with the stream system. Our approach has been to try low-cost alternatives to stream bank erosion prevention, such as cedar (*Juniperus virginiana*) tree revetment, willow (*Salix* spp.) plantings and riparian corridor fencing and revegetation. Rock structures, such as artificial riffles, also have their place when hydraulic factors dictate them. Since the Department has purchased many private tracts in recent years, our own lands reflect other private land conditions. We have been, therefore, refining and demonstrating several of these practices on our own lands and will be establishing a network of demonstrations areas on private lands starting this year.

In order to expedite the development of these demonstration areas, we are entering into cooperative landowner projects to install practices. The installation is made through a joint agreement between the Department and the landowner to share the costs and labor involved in implementing an approved plan. Once this network of demonstration areas is in place, we will use the techniques which have proved valuable in the past decade in watershed land-use treatment. These include landowner workshops and neighbor-to-neighbor tours, along with brochures and videos to teach more riparian landowners the value of the practices and how to install them.

We are sponsoring special incentive programs in cooperation with the Soil and Water Conservation districts in our state to assist and encourage landowners in installing steam improvements. These concepts are experimental in nature so we are providing these incentives on a pilot basis in hopes of finding the best way to expand implementation with minimum expenditure. The incentive practices include: lending specialized equipment needed to install stream improvement structures; cost sharing for several specific improvement practices; and paying for riparian protection established through conservation covenants.

The equipment loan pilot project provides special tools designed to drive anchors into system banks or channel bottoms in preparation for installing steam restoration structures. A Department technician can be made available during the project implementation if technical advice is necessary. This practice is contingent upon an approved conservation plan, including riparian corridor restoration. Six pilot counties have been selected where the Soil and Water Conservation District board has agreed to cooperate.

The cost sharing pilot projects are again in cooperation with the Soil and Water Conservation districts in six counties other than those where the equipment loan projects are being tried. With cost sharing projects, we provide technical advice and assist in the cost of the practices as stipulated in an agreement. Practices selected can include revegetation, livestock exclusion, bank revegetation, tree revetments, riprap, and instream riffle and rootwad structures.

After a landowner applies for one of these practices, Department of Conservation personnel make site specific recommendations which, if acceptable to all parties, become incorporated into a project agreement subject to several project conditions. If the project is of such a scope that a professional engineer's recommendations are needed, the approval of both a professional engineer and a Department Fisheries District supervisor is required. Once the project is installed, cost-share payment is issued through the Soil and Water Conservation District. The landowner is held responsible for project maintenance.

The Stream Stewardship Agreement is a third type of incentive to reward landowners who have maintained sound land-use practices in areas of importance to Department concern for fish, wildlife and forest resources. Under this incentive, landowners would agree to manage their stream corridor lands according to a Department management plan and deed to the Department a permanent easement in return for payments during a ten-year period on an agreed price. Implementation of this incentive program will begin later this calendar year.

Part of the landowner services program has entailed training of both our personnel and personnel from cooperating agencies. This phase has been both arduous and rewarding. A common understanding of stream corridor management concepts has been achieved where one has not existed before, and a common bonding between agency personnel has been reinforced. This effort, alone, has been more than worth the time expended and will likely become a repetitive part of the program. One immediate outcome has been the initial development of riparian management guidelines. Several disciplines and agencies have been involved. The eventual outcome will be a standard by which all may follow in dealing with landowners.

The third aspect of Streams for the Future involves increased emphasis on coordination between other agencies. In addition to the high degree of coordination between our Department and the Soil and Water Conservation districts previously mentioned, we are looking toward involvement in the small watershed improvement efforts of the USDA Soil Conservation Service and the Missouri Department of Natural Resources.

These programs are primarily geared for the river basins and watersheds largely within our state's borders. The state of Missouri, however, has more than 1,000 miles of large rivers—the Missouri and Mississippi. Coordination with other states within these drainage basins and the appropriate federal agencies is the principal approach to solving the important problems facing the degraded resources of these major rivers.

Federal funding for big river habitat improvement through the Missouri River Mitigation Program and the Environmental Management Program will help compensate for past habitat losses. Currently, one Missouri River project has been approved for construction, and several Mississippi River projects have been constructed. Experience to date shows that coordinated efforts are beginning to pay off on the big rivers in a big way.

We see future opportunities in coordination, incentives and public involvement which will likely be written into our strategic plan as Streams for the Future evolves. Our original thesis will likely remain, however: people have been the cause of stream problems; therefore, all people—river users, as well as river landowners and watershed dwellers—must be a part of the solution. In addition, streams have been declining throughout decades; we cannot restore them overnight. This is a long-term program.

If, through our efforts, people begin to look upon Missouri's rivers as a common resource, not to be owned to the exclusion of someone else, then a new era of responsibility and stewardship may be dawning. Streams for the Future, through the creation of a broad, committed constituency may be the catalyst for that end.

Aquatic Project WILD: Establishing Linkages for a Healthy Environment

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Introduction

It is my pleasure to have this opportunity to contribute to the proceedings of this conference. My purpose today is to focus especially on one part of Project WILD, the *Project WILD Aquatic Education Activity Guide*. I will talk with you about its design, including how it fits within the larger Project WILD program, and some of what we are learning from research about its use and contributions to improved education about wildlife and the environment as part of Project WILD.

Aquatic WILD

Design and Purpose

In the "Preface" to the *Project WILD Aquatic Education Activity Guide* (1987), we state: "The waters of the earth, in some form, are walking distance from any classroom on the planet. These Project WILD Aquatic Education materials serve as an invitation to explore and understand the fascinating worlds of water and the aquatic habitats they support. . . . Water, in all its forms, is one of the most dramatic of today's arenas in which informed, responsible, and constructive actions are needed. Water is one of the basic components of habitat for people and wildlife. Water is essential to all life. Aquatic species and aquatic ecosystems give humans early and clear warning about the quality of the watery environment upon which we all depend."

The Project WILD aquatic education program, like all of Project WILD, is "based on the premise that young people and their teachers have a vital interest in learning about the earth as home for people and wildlife. . . . Project WILD is designed to prepare young people for decisions affecting people, wildlife, and their shared home, earth. In the face of pressures of all kinds affecting the quality and sustainability of life on earth as we know it, Project WILD addresses the need for human beings to develop as responsible members of the ecosystem" (WREEC 1983).

All of Project WILD is aimed at this goal: developing informed decision makers who will take responsible action on behalf of wildlife and the quality of the environment, now and in the future. The *Project WILD Aquatic Education Activity Guide*, and the instructional workshops and other support materials and services associated with it, are aimed at that same goal—focusing especially on aquatic species and aquatic ecosystems.

The *Project WILD Aquatic Education Activity Guide* was initially developed in part with support from the U.S. Fish and Wildlife Service Sport Fish Restoration

Funds. This activity guide is now available in all 50 states. I am delighted to announce that the materials in this activity guide are also now available throughout all of Canada except Quebec through Canada's Project WILD program, principally sponsored in Canada by the Canadian Wildlife Federation in cooperation with the provincial and territorial wildlife agencies and departments of education. Canada's sponsorship of Project WILD has been made possible by agreements with and between the founding sponsors of Project WILD in the U.S.—the Western Association of Fish and Wildlife Agencies and the Western Regional Environmental Education Council.

Guiding Assumptions

There are some assumptions that guide all of our work with Project WILD, including the *Project WILD Aquatic Education Activity Guide*. I will share a few with you. For example, we believe it is important that kindergarten through high school teachers work to teach students ecological concepts in order to prepare those students to be informed and responsible decision makers. That seems straightforward enough, but the reality is that there is no systematic, comprehensive approach to integrating education for ecological literacy into the kindergarten through high school curricula of the United States and Canada. The wildlife agencies have taken a stronger leadership role than any other environment-related agencies in North America to help achieve this goal—but we still have a long way to go. So, in the area of assumptions, please don't assume that the educational policy makers of North America—the school superintendents, principals and members of boards of education, for example—are making education for ecological literacy a priority. Not yet.

Another assumption that must be challenged is that once people are provided with accurate, scientifically based information, that information will be translated into practice. If we just go to the schools and tell teachers the facts about wildlife, for example, they will include that information in their teaching and act on it in their lives. Not so. We must provide that accurate, scientifically based information in the context of powerful instructional strategies. We must develop exciting, effective, meaningful ways for teachers and students to learn about wildlife, habitats and responsible actions. So with our development of Project WILD, including the *Project WILD Aquatic Education Activity Guide*, we have placed equal emphasis on both our teaching techniques and our content. That results in our instructional materials and workshops being based on an intentional diversity of teaching and learning approaches and techniques—with a strong emphasis on learners actually getting outside to learn and do real things in the living world.

Something that may surprise you is how ill-prepared most teachers are to go outside and conduct anything like a valid scientific investigation. That is one of the reasons that the Project WILD workshops for teachers are so important. We are teaching teachers as much as we are teaching youth with this program.

I will give you an example. One instructional activity among the 40 offered in the *Project WILD Aquatic Education Activity Guide* is called "Water Canaries" (WREEC 1987). Students investigate a stream or pond using sampling techniques. The objectives are for students to identify several aquatic organisms and to assess the relative environmental quality of that aquatic environment based on indicators of pH, water temperature and diversity of organisms. That sounds simple enough—

but most of today's teachers don't have the experience, skills or background to undertake this kind of basic field investigation. When we take teachers and students outside to conduct these kinds of activities, building other support for them into the process as well, it provides a foundation for us to get to the larger goal of responsible actions and informed decision making. Two areas of the United States serve as examples. In Colorado and in New England, advanced Project WILD program activities—using the *Project WILD Aquatic Education Activity Guide* as a foundation—are focusing on rivers and watersheds. Students are monitoring the quality of the rivers in their region, gathering their data, sharing it by computer networking with students and teachers stationed up and down the river at monitoring sites, and, frequently, as a result of some circumstances they find, taking action to improve the quality of the river for use by humans and wildlife. There are lots of payoffs through such an instructional program and process—but one is that young people are getting authentic experience in monitoring the quality of their environment for people and wildlife, and taking action to protect that quality.

All of this does not happen at once. For us, with Project WILD, it begins with an introductory workshop. Sometimes teachers get the *Project WILD Aquatic Education Activity Guide* at that first workshop, sometimes they receive it when they come back for an advanced workshop. Both approaches are working, however, we do find that the longer the workshop, the more instructional activities the teachers actually incorporate into their curricula (Standage 1991). We also find that, on the whole, teachers know even less about aquatic environments than they do about terrestrial environments—so there is an exceptional need to provide them with opportunities for instructional workshops where they can interact with biologists and educators to learn about aquatic species, ecosystems and issues at the same time they are learning instructional techniques for conveying those concepts to youth. To help meet this need, the advanced Project WILD aquatic education workshop format appears to work better than other models. This is especially true when a teacher participates in such a workshop after she or he has participated in an introductory Project WILD workshop. I will address the evidence for this statement below.

Research Findings

I have mentioned a relationship between length of workshop and number of Project WILD instructional activities used by teachers following the workshop. That is simply one of a variety of useful and important kinds of information we are obtaining from our ongoing efforts to monitor and evaluate the use and effectiveness of Project WILD. I would now like to share a few of the other findings from some of the current research recently completed related to Project WILD, including use of the *Project WILD Aquatic Education Activity Guide* (Standage 1990, 1991).

A major study was undertaken during the spring 1990. Some of the results of this study were reported in the "Project WILD Report of Program Activities from a National Perspective, Summer 1990" (Charles 1990). More detail is included at this time. A full copy of the results is available from the national Project WILD offices. Project WILD Coordinators throughout the United States have been provided their own state's results as well as national and regional information, except in those states in which the program was just getting underway or was not yet available at the time of this survey.

This particular survey, "1990 Project WILD User and Non-User Assessment Study" was conducted by an independent public opinion firm, Standage Accureach, Inc. of Denver, Colorado in June of 1990. Telephone interviews were conducted with 1,330 participants obtained by random sampling techniques from the pool of those who have participated in Project WILD workshops in the United States since the fall of 1983. Where available, comparison to a similar study conducted in 1986 is included in the parentheses following the 1990 results. We are pleased to see the consistency of results from 1986 to 1990, particularly since the population sampled was literally that of the whole Project WILD participant population on record since workshops began in fall 1983. Where there are differences in the results, they tend to be in the direction of greater use in 1990 than in 1986. This suggests that it does take time for teachers to incorporate Project WILD into their curricula following a workshop; where they have indicated their plans to use the materials in the future, the data suggest that they tend to do so. These results include the *Project WILD Aquatic Education Activity Guide*. Here is a sample of what we are learning:

- Nationwide in the United States, 78 percent of those surveyed have used or are using Project WILD in their educational programs following their participation in a Project WILD workshop. Of the 22 percent who report not using the materials, 62 percent indicate they plan to in the future. (In 1986, the national average was a 70 percent rate of use. Of the 30 percent not using the materials, 63 percent indicated they planned to in the future.)
- Ninety-nine and a half percent of those who report using Project WILD indicate their interest in using Project WILD in the future. (In 1986, 98 percent indicated plans or interest in using Project WILD in the future.)
- Eighty-five percent of the users indicate that Project WILD has increased the amount of their teaching time devoted to wildlife and the environment. (This compares with 83 percent in 1986).
- Over 90 percent of the respondents said that their own attitudes had been changed as a result of Project WILD, and that the Project WILD workshop was one of their most valuable sources of professional support for teaching about wildlife and the environment. In fact, nearly 25 percent said that Project WILD is their only source of conservation and environmental education materials for use in their instructional programs.
- Eighty-seven percent of the users report having encouraged others to participate in Project WILD and 80 percent indicate they have loaned or shown their Project WILD activity guide to other educators. Of those, nearly half have loaned or shown Project WILD to four or more others. (In 1986, 75 percent had loaned or shown their Project WILD activity guide to others—with only 14 percent to four or more others.)
- Ninety-nine percent of the users agree that Project WILD provides a balanced and fair approach to the study of wildlife and environmental issues with less than 1 percent disagreeing with that view. (In 1986, 88 percent said that Project WILD provides a balanced and fair approach.)

How much time are teachers spending with Project WILD as part of their curricula?

- Sixty-four percent of the respondents are using seven or more Project WILD activities with their students in a year. (In 1986, 42 percent were using seven or more activities.) Seventy-two percent of those are spending from 30 minutes to more than six hours per each activity. (This compares to 54 percent in 1986).

These are increases and translate to a substantial amount of instructional time in a system that is not currently placing a priority on teaching about wildlife and the environment.

Those using Project WILD report that their students have gained in their awareness, knowledge, skills and attitudes related to wildlife in a variety of ways. For example:

- Ninety-four percent of those using Project WILD report that their students have increased their awareness, knowledge, skills, and/or attitudes about the importance of responsible decision making concerning wildlife and the environment as a result of Project WILD. (This compares with 53 percent in 1986.)

We are concerned not solely about students gaining in awareness, knowledge, skills and attitudes, but whether the students can and do translate this educational gain into constructive actions to benefit wildlife and the environment. In 1990, we asked teachers whether their students have taken action to benefit wildlife and the environment as a result of Project WILD and found that a surprising 96 percent are reported to have done so. Some of their actions may be considered introductory, but they are a place to begin. For example, nationwide, 81 percent have cleaned up litter, 78 percent have participated in recycling projects, 27 percent have written letters to local or state officials about environmental issues, and 21 percent have built nestboxes. More difficult, 32 percent have created schoolyard habitat projects. We are expanding our efforts to assist students and their teachers to take responsible action to benefit wildlife and the environment—action that is appropriate to the age and maturity of the students as well as appropriate to the needs of their communities. This year's annual Project WILD Coordinators' Conference—the first joint Canadian/U.S. Project WILD Coordinators' Conference, being held June 1–6 in Lethbridge, Alberta, Canada—will include a session on conducting wildlife action worships for teachers and students, with a major emphasis on habitat improvement.

Some of our findings have a direct bearing on wildlife agency strategies for support of wildlife education, including Project WILD and its aquatic component. For example, we clearly find that those educators who participate in workshops of nine hours or longer are more likely than those in shorter workshops to use more than ten Project WILD activities per year with their students following the workshop (Standage 1991). Other research related to Project WILD indicates that where teachers use seven or more activities in a school year, there is statistical significance in gain in student knowledge and attitudes consistent with the goal of Project WILD—so there is value in looking for ways to increase the number of activities that teachers use in any given school year (Fleming 1983).

Workshops are important for a variety of reasons. One notable example is specific to the *Project WILD Aquatic Education Activity Guide*. As policy, it is possible in some states to obtain a *Project WILD Aquatic Education Activity Guide* through the mail if an educator has previously attended an introductory Project WILD workshop. Only in the instance of prior Project WILD workshop experience is this allowed. Our recent "1990 Project WILD User and Non-User Assessment Study" shows that those who receive this activity guide through the mail are much less likely to use the guide than are those who receive it in a workshop. Those who receive the aquatic guide at a Project WILD aquatic education workshop have a higher rate of use than those who receive this guide at a workshop where they receive both an elementary or secondary guide and an aquatic guide. The Project WILD Management Committee has had concerns about overwhelming teachers with too much in one workshop where they receive more than one activity guide. This finding would appear to support that concern. Eighty-three percent of those who obtain a *Project WILD Aquatic Education Activity Guide* at a specifically Project WILD aquatic workshop report using the guide, compared with 62 percent who obtain the aquatic guide at a workshop combined with an elementary or secondary Project WILD activity guide, and compared to 50 percent use by those who receive the aquatic guide through the mail. According to the independent opinion firm, "Specific use of the aquatic guide nearly doubles for each additional Project WILD workshop attended. This may imply that given the amount of material presented at an initial Project WILD workshop, additional workshop attendance is needed to absorb the aquatic material" (Standage 1991). It has always been the recommendation and preference of the Project WILD Management Committee that the aquatic education activity guide be offered in the context of a specialized, preferably advanced, Project WILD aquatic education workshop; this research appears to support that recommendation.

Another finding of interest directly related to the *Project WILD Aquatic Education Activity Guide* has to do with secondary teachers. Historically, more elementary than secondary teachers participate in Project WILD workshops. Approximately 70 percent of Project WILD teachers are those who teach kindergarten through sixth grade students. However, our current research shows that seventh through ninth grade teachers are the most frequent users of the *Project WILD Aquatic Education Activity Guide*, followed by tenth through twelfth grade teachers, and finally by elementary teachers. We are pleased with this finding because it suggests that the *Project WILD Aquatic Education Activity Guide* is assisting us in reaching secondary teachers.

Another research finding that speaks to Project WILD's increasingly widespread use comes to us from a study conducted by *Science and Children*, the professional journal of the National Science Teachers Association aimed at preschool through middle school teachers. In an article published in the February 1991 issue, it is reported that Project WILD is used by 41 percent of the elementary teachers who subscribe to *Science and Children* and participated in this study (Kyle et al. 1991). While we are delighted with this report, I do think it is important to mention that teachers who subscribe to *Science and Children* and are members of the National Science Teachers Association are probably more likely to be including concepts related to science and the environment in their curricula than are most other elementary teachers who tend, on the whole, to lack confidence in these areas. I should note that one of the major reasons we use a workshop approach to providing the Project WILD instructional materials to teachers is to give them wildlife knowledge accompanied with experience in using teaching techniques that will assist them—helping substantially to overcome the fear of teaching anything science-related that many elementary teachers have.

The point is that while 41 percent of this population of more science-oriented elementary teachers is reported to be using Project WILD, we do not yet find the Project WILD materials being used by such a significant percentage of all teachers nationwide. We are making progress, but it is not yet that dramatic! There are some states, however, that have provided Project WILD workshops for as many as 50 percent of the number of teachers in their states. Nationwide, since fall 1983 when workshops began, we have now reached more than 10 percent of the number of teachers in the U.S. We are reaching approximately 50,000 teachers annually in workshops offered in all 50 states, bringing the total to date to more than 300,000 educators who, in turn, have reached more than 25 million students.

While it is correct that the data indicate teachers are using Project WILD in increasing numbers, we are continually looking for ways to reach more educators, more effectively; to support all those we reach with additional materials and services to the extent possible and useful; and to assist those who get involved to do even more—systematically, comprehensively and with quality.

For example, when asked in the "1990 Project WILD User and Non-User Assessment Study" about things that could help them include Project WILD activities in their curricula more easily and effectively:

- 96 percent said having an opportunity to attend additional Project WILD workshops;
- 93 percent said having additional materials from Project WILD to supplement the activity guides;
- 89 percent said having additional planning time;
- 82 percent said having a cross-reference between Project WILD and textbooks they use;
- 80 percent said having a correlation between Project WILD and their state's curriculum guidelines;
- 75 percent said having encouragement from the school administration to use Project WILD; and
- 74 percent said coordination with other teachers in their school to decide who would use which activities at which grade levels and at what time of the school year.

We are clearly learning a variety of useful and interesting things from our continuing research. We will work with these results, particularly through the Project WILD Coordinators and our national level Project WILD Management Committee, in order to continually improve this program and its contributions in turn to the wildlife education efforts available in North America and, increasingly, other parts of the world.

It is especially through the leadership of the state and provincial wildlife agencies that this progress is being made. Your efforts are appreciated and are being increasingly noticed—including by educational policy makers. We must continue to work creatively and in partnership with the education community in order to improve the educational experience available to kindergarten through high school youth and their teachers. Although the challenge we face in developing an informed citizenry that will take responsible actions to benefit wildlife and the environment remains formidable, there are indicators of progress. Without the financial and personnel resources of the state and provincial wildlife agencies, this progress would not be made. Thank you for your continuing commitment to this challenge.

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Special Session 6. *Cooperating with Indigenous People to Manage Fish and Wildlife*

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The Beverly and Kaminuriak Caribou Management Board: An Example of Cooperative Management

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Introduction

Management of the Beverly and Kaminuriak herds of barren ground caribou (*Rangifer tarandus groenlandicus*), that range in northern Manitoba, northern Saskatchewan and the Northwest Territories (Figure 1), has been a topic of discussion for years among government officials, wildlife professionals and caribou users. In the late 1970s, population estimates gave rise to the concern that the Kaminuriak herd faced possible extinction within a decade. The Kaminuriak herd was estimated at 44,000 animals in 1977 (Simmons et al. 1979) and 39,000 in 1980 (Gates 1985), down from more than 145,000 in the 1940s and early 1950s. This represented an apparent serious decline. The Beverly herd, in a similar decline, was estimated at 94,000 animals in 1980, down from 177,000 in the previous census of 1974 (Beverly and Kaminuriak Caribou Management Board 1985). To respond to the perceived crisis (although those population estimates might have been based on inadequate or

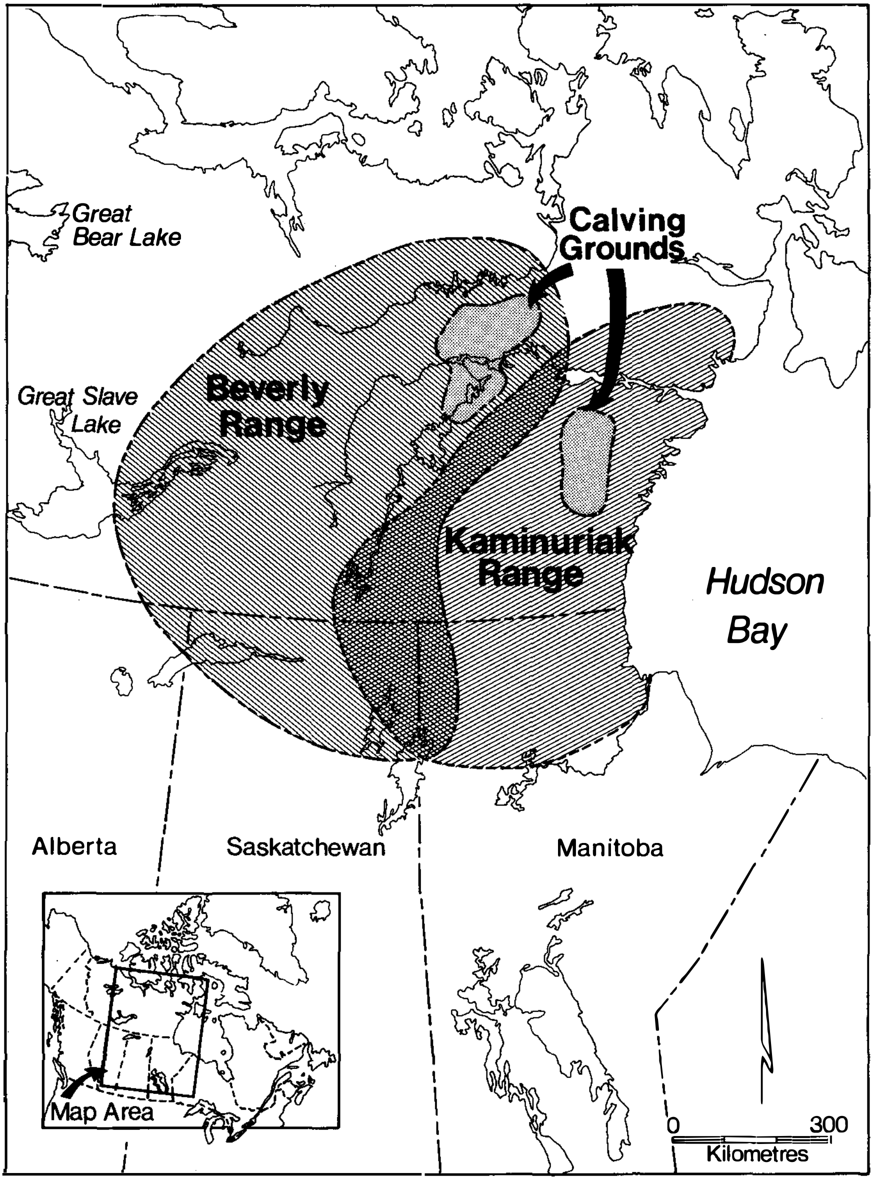

Figure 1. Ranges of the Beverly and Kaminuriak caribou herds and their calving grounds.

inaccurate surveys) an interim group representing government agencies was established in late 1979.

Some Inuit, Indian and Métis users of the herds frequently pointed to the obvious inadequacy of the management process, and refused to accept population data in light of their own experiences on the land. The users claimed that the animals had merely "moved over there" and that government surveys were deficient. Government representatives recognized that changes in management strategy and philosophy were needed but were unwilling to accept the caribou users' insistence that their traditional knowledge and practices gave them the right to manage the caribou resource in their own way. All parties agreed that bickering did absolutely nothing to secure an irreplaceable and valuable heritage and that management action would be ineffective without the involvement and support of the users. Governments clearly needed to devote more time and effort to understanding those people who utilized the resource and, furthermore, to avoid disrupting their traditions without fully understanding their nature and strengths. For the sake of both the caribou and users, some mechanism was necessary to "marry" the two opposing positions, which ranged from exclusive native jurisdiction to complete government control.

Establishment of the Caribou Management Board

Strident negotiations, "backroom" conversations and formal positions from both sides culminated on June 3, 1982 in a 10-year management agreement establishing the Beverly and Kaminuriak Caribou Management Board (hereafter referred to as the Board). Since the federal, provincial and territorial government departments were to provide the necessary administrative funding, they comprised the five signatories to the management agreement. Specifically, the departments included: Indian Affairs and Northern Development; Environment Canada; Manitoba Department of Natural Resources; Saskatchewan Department of Parks and Renewable Resources; and the Northwest Territories Department of Renewable Resources. Because the users could not be partners to the agreement, government signatures were witnessed by native organizations, including representatives from the Métis Association of the Northwest Territories, the Northern Manitoba Tribal Council and a northern Manitoba Chipewyan Band.

The Board has 13 members—5 government members and 8 user members representing native peoples and/or their associations. The Board user members are geographically located within the ranges of the two herds. Members include the Inuit of Keewatin and Chipewyan bands of northern Manitoba. Other user members represent the Lake Athabasca and Wollaston Lake regions in Saskatchewan and communities south and east of Great Slave Lake in the Northwest Territories. The geographic jurisdiction of the Board is defined by herd boundaries, not by political ones.

The Board's objectives, as defined by the management agreement, are to: 1) coordinate management of the herds in the interests of traditional users; 2) establish a process of shared responsibility for the development of management programs; 3) establish communication among traditional users and governments in the interests of coordinated caribou conservation and caribou habitat protection; and 4) discharge the collective responsibilities for the conservation and management of caribou and caribou habitat.

As stipulated in the management agreement, the Board's assigned duties and responsibilities are to: 1) make recommendations to governments and user groups for the conservation and management of the herds and their habitat, in order to restore them—as far as reasonably possible—to a size and quality that will sustain the requirements of traditional users; 2) monitor caribou habitat to promote better maintenance of a productive habitat; 3) conduct an information program; and 4) assess and report on the operation of its heard management plan to governments and traditional user groups.

The balance of this paper will review the major activities of this interjurisdictional and participatory Board during the eight years since 1982, the reasons for its successes, and the challenges yet to be faced.

Major Activities of the Board

Information, Education and Communication

It was immediately apparent that information, education and communication about the aspects of caribou biology, management and use were essential first steps to be addressed. For example, Inuit Board members reported large numbers of caribou and good harvest levels near their communities, whereas Manitoba Chipewyan members could report only occasional sightings. These differences in caribou availability were not widely known until group discussions were initiated at Board meetings. Previously, there were very different expectations among the communities. For example, some Inuit pressed for commercial sale of caribou meat, while users in Manitoba were often unable to obtain even one animal for personal consumption.

To improve understanding between user groups and between users and wildlife managers, the Board undertook a video program in the Inuit communities of the Keewatin. The purpose of the project was to record on video tape the unedited views of both Inuit and wildlife managers on a range of topics related to caribou. Attitudinal changes, hopefully, could be brought about through the use of that program. Copies of the video were provided to other traditional users, government administrators and biologists so that they could learn of the various views and discuss them in public fora in a non-confrontational manner.

The video program was an important first step in the easing of tension between wildlife managers and users. Attempts to extend the program to Indian and Métis user communities were unsuccessful, unfortunately, due to lack of funding support from government and private sources.

In another important initiative, the Board reached out to users and others concerned with caribou management by establishing a bimonthly newsletter. *Caribou News* was first published in May 1918 and continues to be published every two months. It is financed by subscriptions purchased by the government jurisdictions for distribution to their own particular user groups. The newsletter costs about $100,000 per year.

Caribou News has made a decisive contribution to the Board's efforts to achieve consensus among caribou users and others by reflecting the attitudes and opinions of all sides in matters of caribou management and habitat protection. The Board's view has been that this expression of opinion has helped remove the barriers to understanding; and, it also has provided a forum in which differences can be debated and resolved constructively.

The publication became successful, in part, by providing its readership with a variety of articles supported by color printing, photographs, graphic illustrations and cartoons. The writing style has been attuned to those for whom English is often a second language. Translation of some material into native languages and orthographies has further enhanced the effectiveness of *Caribou News*.

Lougheed and Associates (1987), in conducting an independent evaluation of the effectiveness of *Caribou News*, list various evidences of success, including wide readership, and the recommendation for continuance of the newspaper. Other comments have been even more laudatory. As quoted by Nortext (1990), Rich Goulden, an Assistant Deputy Minister with Manitoba Natural Resources, stated "The communication of information, both ways, from the users to the government and back the other way, had to be absolutely fundamental. That brought into being *Caribou News*, which is still the best newspaper, in my view, about a natural resource management initiative any place that I've ever seen."

Board members unanimously agreed that a program was required to ensure that native children grow up understanding the resource. The Board thus authorized the development of an innovative Schools Program in collaboration with education authorities, local school boards and committees, and other interested organizations and individuals on the caribou ranges. The four-unit program was completed in 1986 with major funding from Indian Affairs and Northern Development. The program covers four topic areas: the barren ground caribou; the value of barren ground caribou; the traditional users; and problems and solutions. It consists of boxed kits containing lesson plans, desk work for students, teacher's guides, and supplementary materials including videotapes, slides, posters, wall charts and games. The program has been accepted with enthusiasm by many community teachers. An independent evaluation (Nortext 1987) found the schools program to be ". . . in place, operating, and reasonably successful in attaining its objectives." Recently, negotiations have commenced to have the Schools Program officially added to provincial and territorial school curricula and some in-service workshops for teachers were instituted to make more effective use of the program.

On the advice of experienced northern adult educators, the Schools Program was expanded, by the publication of an Adult Educator's Guide to accommodate adults interested in caribou management topics. It has also been used for academic upgrading because the subject matter was of local interest and within the daily experience of most students. In a further expansion of the program, a Chipewyan-language supplement was developed for use in Saskatchewan community schools.

The Board wanted to raise its profile amongst the primary users of the resource by convening meetings within their communities. Considerable effort and expense has been devoted to holding Board meetings in isolated communities on the caribou range. Board meetings were open to the public, and, consequently, provided an opportunity for a variety of interested people to attend. Special "question-and-answer" sessions are held as another means of information exchange with users to encourage community input. Some user meetings were productive; others were disappointing. Likewise, the success of user members on the Board to function as a conduit on caribou issues to the communities they represent has been limited.

Other initiatives have included a six-part radio series called Caribou Radio which was produced and broadcast in English and native languages to the caribou-using communities. Topics have ranged from the potential threat of uranium mining, to the protection of caribou calving grounds, to a variety of caribou stories told by listeners. News releases were produced immediately following many meetings to inform the public of the activities of the Board. A travelling display on the caribou range and Board activities was also prepared for use within the caribou range and for audiences in the south. An annual report, as called for by the management agreement, has been produced and distributed to agencies to convey progress made by the Board. New efforts in education and communication, which were developed as part of the management plan, include the establishment of a scholarship fund, the introduction of a caribou poster and prose competition in schools on the caribou range, and the use of Board subcommittees to visit user communities.

Development of a Management Plan

A major thrust was the formulation of a comprehensive management plan to guide the multi-jurisdictional management of the Beverly and Kaminuriak caribou herds. The plan established management principles and population goals and objectives, and then describes action plans to achieve these aims (Beverly and Kaminuriak Caribou Management Board 1986). The two goals established by the Board in the management plan are: (1) "to safeguard the caribou of the Beverly and Kaminuriak herds so that the traditional users can maintain their options of a lifestyle that includes the use of caribou"; and (2) "to safeguard the caribou of the Beverly and Kaminuriak herds in the interests of all Canadians, as well as people of other nations."

The details of the program are described in a series of 15 action plans set out in four sections (Figure 2). Before the plan was finalized, it was subjected to public review, approval by a Users' Assembly and review by an independent subcommittee led by an academic. The long-term management plan remains subject to periodic review.

The management plan sets out objectives for the optimum size for each herd at 300,000 animals, based on user demand and government managers' views of the ability of the habitat to support caribou. A decline below 150,000 animals in either herd is to be considered a crisis level, requiring recommendations from the Board

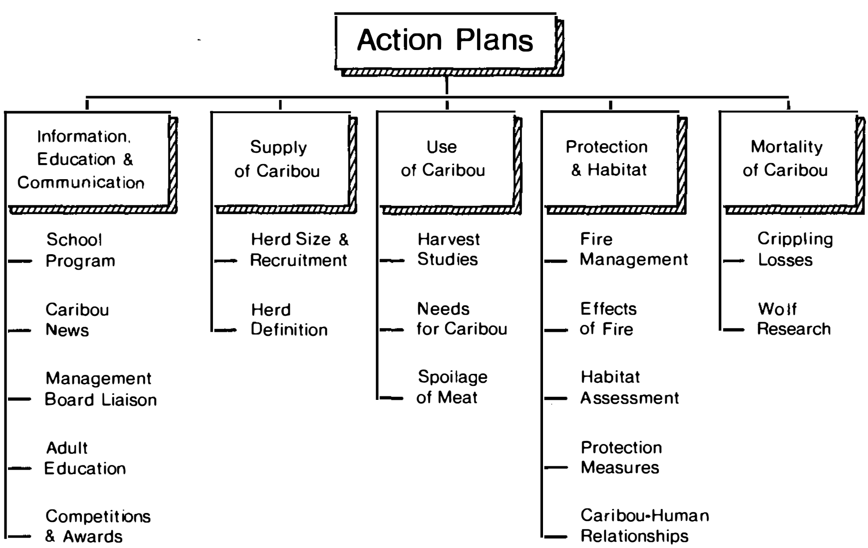

Figure 2. Action plans developed from the goals and objectives of the comprehensive Beverly and Kaminuriak caribou management plan.

to reverse the decline. Additional objectives of the management plan are: to ensure that caribou are accessible and available to traditional users; to increase knowledge of caribou ecology; to encourage the wise use of caribou; to involve local individuals and organizations in management programs; and to strengthen public support for the conservation of caribou.

Other Activities

The Board has pursued other activities to enhance the caribou resource and habitat. The Board formally recommended the adoption of a photographic method to replace the observer head count method previously used in surveys of caribou calving grounds. The data are combined with those from ground-based composition surveys and estimates of caribou fecundity and adult sex ratios to arrive at caribou numbers. Users are now directly involved in visual surveys because of the insistence of the Board. On the basis of these surveys, the population in 1987 was estimated at 190,000 ± 71,000 SE for the Beverly herd (Heard et al. 1990) and in 1988 at 220,000 ± 72,000 SE for the Kaminuriak herd (Heard and Jackson 1990).

The Board is currently preparing recommendations to participant governments concerning fire-fighting responsibilities in the jurisdictions, as well as resolutions on key areas requiring government protection. It has also documented human activities on and over those caribou ranges that need scrutiny. Prominent among the concerns were the following: a federal government proposal to review the status of the Thelon Game Sanctuary; a proposed uranium mine east of the Sanctuary; NORAD low-level flights over the Beverly herd winter range; a hydro transmission line built on the Beverly winter range in Saskatchewan; and mineral explorations on or near the Kaminuriak caribou calving grounds.

In 1986, the federal government issues its Northern Mineral Policy, declaring that the status of the Thelon Game Sanctuary would be reviewed. That Sanctuary is extensively used by the Beverly herd during its migration, sometimes for calving, and always for grazing during the vital post-calving period. After considering the matter, the Board maintained its opposition to any changes of the boundaries, and to any exploration and development being permitted within the Sanctuary.

The Board also tackled such thorny issues as priority use of caribou, commercial quotas, nonresident license hunting requests and bag limits of resident hunters in the Northwest Territories. After lengthy discussion and consultation, the Board established a priority list for the use of caribou. The highest priority was accorded to traditional users' domestic use, followed by residential users' domestic use, traditional users' intersettlement trade, traditional/resident users' non-resident hunting (such as guiding), local use for commercial purposes and, lastly, export use for commercial purposes.

After much negotiation and debate, the Board recommended pilot commercial local use quotas of 250 animals for the Fort Smith Hunters and Trappers Association and a similar quota of 350 to the Keewatin Hunters and Trappers Association. Stringent reporting requirements were attached to these quota recommendations. The meat is to be used for sale in country food stores in Fort Smith, in some communities in the Keewatin, and for the export of up to 100 caribou for Inuit consumption at the Churchill and Winnipeg Transient centres and at the Winnipeg Health Science Centre. In conjunction with these quotas, the Board also recommended restoration of a previous limit of five caribou per license for resident hunters of the Northwest Territories from the 1986 limit of two.

The demands for commercial quotas have been treated very conservatively and against the wishes of a minority of Board members. The approved commercial harvests of 600 animals represents a small fraction of the estimated annual harvest of 19,000 caribou from the two herds. The foregoing examples illustrate that the Board does not wish to support ventures that are ecologically unsustainable.

Reasons for the Success of the Board

To date, the Board has often been regarded as a model for cooperative management and its operation has been studied in detail (Gordon 1985, Osherenko 1988a, 1988b, Cizek 1990) and observed by several groups interested in cooperative management of resources. Apart from reviews of others, I would like to present my impression of why the Board has been, perhaps, more successful than the other caribou boards or caribou committees on which I have served during more than 30 years. My insight has developed as a result of being involved in the drafting of the agreement establishing the Board, and in serving on both the interim and present Board.

In the strictest sense, the Board is only advisory. In practice, however, governments have followed its advice on overall herd management although not on habitat protection matters relative to fire control on the winter range, or complete protection of the calving grounds. The Board will be ineffective without the acceptance by governments of a large proportion of its recommendations. Governments have, therefore, contributed to the Board's success by implementing many of its recommendations. The fact that all recommendations have not been accepted by governments does not concern me. There is no reason to believe that all recommendations from any board are biologically, financially, socially and politically feasible. I would, in fact, be more concerned if all recommendations were accepted by governments because some may be unwise and others self-serving. An example is the demand for fire control. That demand from some users is related more to security of cabins and traplines and fire-fighting employment than a real conviction for its need from an ecological perspective.

Decisions of the Board are most often based on consensus. A few issues, such as commercial use quotas, polarized into conflicts between members, but never into government-user splits. This is, perhaps, the best evidence that the Board is indeed a useful, working partnership. It is in marked contrast to the period of claims and counterclaims that earlier fostered a climate of confrontation.

Success has been brought about in large part because of the work of individual members on the Board. Government members have tried to be responsive to user concerns. Several government members are senior managers, thus they were able to make immediate policy decisions that were important to users without the great delays often experienced in bureaucracies. Some examples are the transportation of meat across jurisdictional boundaries and elimination of the regulation requiring hunters to wait 12 hours after landing an airplane before hunting caribou. In addition, some members have had discretionary funding for major projects endorsed by the Board.

Patience has been a major virtue of the Board. The management plan, which took nearly three years to develop, perhaps could have been completed in a few weeks.

But it was fundamentally important that everyone understand the plan and be prepared to defend it in their communities or agencies. For example, many users wanted a wolf control program to help supplement caribou numbers. To the users—who knew the population of wolves in their areas and number of caribou taken by them—it was a simple task to calculate the potential caribou increase from such action. However, the concept of compensation in wolf populations, where the reproductive rate may be increased to redress losses, required several lengthy discussions before it was understood by all parties. Government Board members and their support teams recognized the users' need for details and consequently developed the management plan in a very cautious and methodical manner.

The users demonstrated remarkable courage in abandoning past positions. One such position was that permission to radiocollar and eartag caribou would never be given. Once the user members heard what the advantages were to radiocollaring, permission for radiocollaring in the Keewatin was obtained. This is but one of several examples where Board members have learned to work together as colleagues for the better management of caribou. Additionally, such commitment has led to solid teamwork and camaraderie forged from many long discussions, living and working together, baptism by fire at public meetings, and a common concern for the resource.

Users constitute a majority on the Board, so government representatives can be "out-voted" at any time. As a result, Government members have been attuned to and respectful of user input in developing the management plan and other issues. Government members clearly recognized that decisions made with full understanding and support of the users would likely need little enforcement. Conversely, imposed rules that run contrary to traditions and users' wishes will likely be met with resistance.

Communication has been, and still is, the most important single factor in developing this new harmony in caribou management.

Another reason for the effectiveness of the Board has been the continuity of board membership. Many members have served for lengthy intervals which subsequently has reduced the time required for orientation of new members. For example, James Schaefer, representing the Métis Association of the Northwest Territories, was elected as the first chairman of the Board, and he served with distinction in that capacity for seven years. Several members have served on the Board since its inception. A great deal of trust and personal friendships have developed—contributing to the overall effectiveness of the Board.

The Board employed an executive secretary to serve members and to carry out the day-to-day operational functions between meetings. As a result, news releases were prepared immediately after meetings and detailed minutes of meetings were available within a very few days. That experience was in sharp contrast to other boards on which I have served where the minutes were often assigned to someone already with a full-time job, and were seldom produced and distributed on a timely basis.

In their function as Board members, government representatives and user members alike have become full partners in managing the caribou resources. In turn, the users are participating and helping to make the Board work—seeing themselves as part owners of it along with government. User participation and leadership on compelling issues has been actively encouraged by government members to ensure that cooperation becomes a reality in practice and not just on paper. In general, user members tend to be less active on administrative and procedural matters, but instead hold effective separate user meetings at the time when administrative matters are being discussed by government representatives. Increased expression and articulation of users' viewpoints and concerns have resulted.

The structure of the Board has given users a sense of ownership in the resource and the decision-making process by giving them the opportunity for the majority vote on any issue. That arrangement accorded them a substantial role beyond that of consultants or advisors. The user-dominated composition of the Board has placed much more emphasis on consensus decision-making. The cooperative management of these caribou herds does not require that government agencies relinquish or transfer any legal authority; it only requires that government authorities share decision-making with user groups and respond promptly and formally to recommendations.

The cooperative management of caribou within these two herds is also a recognition that government authorities cannot manage these resources without cooperation of the user groups. Over such a large and sparsely populated area, little compliance can be expected for major management decisions with which the user groups do not concur.

The Board is supported by governments, in part, because it is cost effective. For example, the total budget for Board expenses and government activities conducted in conformance with the management plan in 1989–90 was $693,100, including 8.7 person-years. That is a modest figure when related to the estimated annual value of hides and meat from those two herds of $12,907,000 annually (Department of Renewable Resources 1990).

The Board does not undertake scientific research; it relies on government departments to act on its research recommendations. To plan, manage and evaluate major research is beyond the capability and mandate of the Board. As some of the government agencies involved have well established research programs, the option of using their experienced research staffs to carrying out research avoids needless duplication and expense. The Board has funded computer-based mapping of fires on the winter range of the two herds (Turney and Gray 1990).

The World Commission on Environment and Development (1987) advocated sustainable development which accommodates the present with a responsible eye to the future. Canada responded to that challenge with an overall strategy to anticipate and prevent environmental degradation by encouraging institutional change, and by demonstrating leadership and improving the information basis for decisions. Included also is a strategy for an abundance of wildlife to provide social and economic benefits. According to Davidson and Thompson (1990), the mandate of the Board embodies all nine approaches to decision-making for sustainable development as outlined by Gardner (1990).

Challenges to the Board

Throughout most of the 1980s, increasing or stable caribou populations in both herds, along with improved survey techniques that revealed more caribou than earlier aerial surveys had indicated, has resulted in relatively harmonious Board operations. Expanding or stable populations of caribou have made hard allocation decisions among communities unnecessary. The Board has wisely used this period to set priorities for demands on the caribou. Although the caribou populations are possibly secure at the moment, that may not continue indefinitely. When the next caribou crisis occurs, the priority list for meeting demands will provide step-wise rationale for the reduction of the harvest.

The Board, to its credit, has taken steps during a time of surplus to make decisions easier during a crisis. But the real test for the Board will be its ability to manage the caribou resource during intervals of population decline when allocation among communities is required.

Those herds could become vulnerable because of increasing demands by a rapidly expanding user population which doubles every 18–20 years, unless the pattern of use changes. There is some speculation, however, that future demands for caribou will not increase in synchrony with the increase of the human population. New herd goals may have to be set accordingly and will require much improved harvest and population data. The confidence intervals around the present population estimates are much too wide to be of any use in management of the two herds. The proposed plan is to survey the herds every six years, which, in my opinion, will prove to be inadequate for management purposes. Harvest data, in general, have been inadequate and expensive to obtain. Therefore, major new initiatives are needed to collect more precise harvest and population estimates.

Another challenge to the Board may come about from land claims settlements that give aboriginal people unique priority rights. Wildlife management boards will be established from each land settlement, but how such boards will link to each other has not been determined.

The Board terminates in 1992 unless it is renewed. A consensus appears to be emerging that the Board can continue to play a valuable role in the future as both a co-management forum involving users and governments, and as an interjurisdictional coordinating agency to advise the governments that support it. To this end, the Board has retained, on its own initiative, an independent consultant who will examine its usefulness and effectiveness. Amongst other things, the consultant will also examine (1) the effects of possible changes in caribou supply and demand on the role and effectiveness of the Board; and (2) the possible relationship of the Board to emerging claims-based institutions, developments such as devolution and possible division of the Northwest Territories, and land use planning.

Conclusions

The Beverly and Kaminuriak Caribou Management Board has combined science with the unique knowledge and cultural practices of the users. It has succeeded because of a strong chairman, long membership tenures, mutual respect among the members and a high level of government support. In the future, to perpetuate this successful model for cooperative management of an important renewable resource, the Board must continue to blend traditional knowledge and practices with modern wildlife science. The real test of the Board will come when caribou numbers decline and herd allocation choices must be made. In my view, the Board is also an excellent example of the sustainable development concept in action. It should be continued past 1992.

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One Caribou Herd, Two Native Cultures, Five Political Systems: Consensus Management on the Porcupine Caribou Range

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Introduction

Regardless of whether its fish or fur or caribou, wildlife management in the north always involves those who make the rules (i.e., governments) and those who must live by them (i.e., the public in general and native cultures in particular). Until recently, there was not much cooperation between these two groups and, thus, a certain amount of mistrust existed which occasionally erupted into bitter public disputes about management policies.

But with the north's coming of age through industrial developments and land claim settlements, a new reality is emerging. And that reality acknowledges the permanence and authority of native cultures plus the need to incorporate native values and native methods in governmental systems.

The Co-management Approach

Co-management of renewable resources is a step in this direction. Through the establishment of co-management agreements between governments and native organizations, the non-native establishment is providing a means of involving native people from the communities in management decisions that previously had been made only by politicians or bureaucrats. And while there is a trend towards more native politicians in the north, you will still find very few native people in upper levels of the bureaucracy because, under existing criteria, few natives have the required qualifications.

One version of co-management is to make an "end run" around this situation by creating advisory boards consisting of classically educated bureaucrats and traditionally educated native members. This brings the two ways of thinking together but it will only succeed if those involved are sincere about incorporating native styles into the system. The problem is that because advisory boards are essentially government creations, there is a tendency to operate them along typical government lines. And so it takes conscientious effort to modify such methods to enhance native input.

A good example of this is management by consensus as practiced by the Porcupine Caribou Management Board.

Consensus Management in Canadian Porcupine Caribou Affairs

The co-management agreement. Prior to the 1970s, native people had very little involvement in Porcupine Caribou management. If any wildlife problem arose, it was tackled by southern biologists who wrote long reports for the bureaucracies which in turn handed down decisions to the communities.

This relationship persisted until the north became valuable to big industry. In eastern Canada it was hydro power and in the west it was oil. This forced the need for governments to confront native cultures and actually pay attention to what they wanted in the way of change.

Although the native communities in the northern Yukon and the MacKenzie Delta had long been advocating co-operative management of the Porcupine Caribou Herd, the first time they were seriously listened to was during the MacKenzie Valley Pipeline Enquiry in the mid-1970s. Still, it was not until 1985 that a co-management agreement was signed by the two territorial governments, the federal government and four native organizations representing the Gwichin and Inuvialuit of the region.

The agreement provided for an eight-man advisory board with equal native and government representation. However, since the Yukon Government has chosen to appoint a native as one of its two members, there has always been a native majority on the Board. But as we shall see, under consensus management, having a majority is of little consequence.

The Porcupine Caribou Management Board. At the first operational meeting of the Board in 1986 the native members stated that they preferred to operate by consensus. What they meant was that they preferred to work on an issue until all the members of the board agreed on a course of action. The alternative, of course, is to let a majority vote determine the decision. Thus, the native contingent, if they wished, could have ruled the day. But this is not their way.

Although the Board agreed to adopt this principle, it was not without misgiving, since, at that time, some of the member organizations were not on the best of terms. Naturally they feared that, lacking consensus, the Board would bog down in endless wrangles and never achieve anything. Sort of like Meech Lake.

However, this did not happen. And in the five years of the Board's operation, in which it has accomplished a great deal, only one motion has been defeated and one passed by a split vote. All the rest have been unanimously supported.

In addition to its internal operation, the Board also applies the consensus approach to the user communities from whence the principle arose. And, so far, in all the major decisions made by the Board there has not been one dissenting community, even when the issues have been highly controversial.

So, consensus management does work, and I would now like to tell you how and why it works.

Components of Successful Consensus Management

Communication

The bedrock of successful co-management is communication. Basically, you can't get everyone to cooperate until they know what's going on and, just as importantly, until they've had their say about it. Communication was the first concern raised at the Board's very first meeting because the biggest complaint the communities had was they didn't know what was happening with the Porcupine Caribou Herd.

Communication is a deceptively complicated task. It looks so easy to address and yet its so hard to be effective. Above all, communication must be tailored to ensure understanding and dialogue. Unfortunately, communication is hidebound by convention and it takes real effort, especially for the bureaucratic establishment, to be imaginative, flexible and even daring.

Fortunately, our funding parties have been very good about such matters, so when we dedicate communication money to ball caps and coffee mugs, there may be a few raised eyebrows and a sharp intake of breath but the funds always come through. And the fact is that more people will remember the goals of Porcupine Caribou Management from reading them on the backs of our coffee mugs than from skimming through them in a management plan.

Over half of the Board's operating budget is devoted to communication which consists of the following major programs:

Community meetings. Whenever possible, the Board holds its regular meetings in user communities. This is logistically more expensive and time consuming but it gives the residents an opportunity to meet the Board, see how it operates and to express their opinions to it directly. Conversely, it gives the Board members a tangible context for the community, its residents and the region as a whole. And above all, making the effort to meet in the communities shows sincere respect for the users of the Porcupine Caribou Herd.

Media. For the past five years the Board has produced a bi-weekly radio report which is aired by local and regional stations. These bulletins are extremely effective because they reach everybody, whether they're at home, on the trapline, driving their truck or in their shop. The bulletins are also translated by several native stations so that elders can hear the news and keep up-to-date on Porcupine Caribou affairs. An added bonus is that the bulletins are often used as springboards for feature interviews on current topics.

The Board also produces a monthly newspaper column which appears in Canada and Alaska. The column amplifies particular management issues and reaches both users of the herd and others who are less directly involved but, nevertheless, quite interested in such matters.

The Board has made a particular effort to take advantage of television for communication through the production of public service announcements, documentaries and educational programs. It is also experimenting with "interactive videos" which are low budget productions aimed at the user communities for discussion of particular problems. Such videos take the place of background reports which are notoriously ineffective in such situations.

Consultation. Anyone who has worked on aboriginal claims will recognize this strategy, since native people rely heavily on 'consultation' as their chief method of establishing consensus. In recognition of this preference, the Board also utilizes consultation both as a regular procedure and particularly to resolve complex issues.

After every Board meeting, the user representatives meet with community organizations to update them on Board work and to get feedback on particular items. And on thorny issues, special public meetings are held to ensure full public input.

Paperwork. You will notice that paperwork appears last on this list. This is because paperwork is the least effective form of communication for co-management. Everyone is always swamped with paperwork, both in the bureaucracies and in the communities. At a recent Board meeting, one of our members told how he had sent a battery of background reports to one community in preparation for some management discussions. When he arrived in the community several weeks later, he found his unwrapped packages of reports functioning effectively—as paper weights for a large map the people were working on.

Although the Board does produce various reports, if these are intended for public use the format minimizes text and emphasizes maps, tables and illustrations to carry the message. Correspondence is also kept to minimum and the Board even condenses its minutes to a two-page special edition for public distribution.

The fact is that no one in the co-management sphere can afford the time to study detailed reports, which is how the executive summary was invented. And our Board has made the startling discovery that most of the time the summary is all that is needed. We have since applied this with great success to such heavy-duty projects as our management plan which is the briefest document of its kind in existence.

Patience

Most of us live in an impatient world. A world that champions growth, progress and promotion. But if you were to step out of that impatient world into one of our northern communities you would see a different pace of life—a pace that allows for more patience and time enough for consensus.

Patience is essential to the consensus process but it can be a hard art to learn. However, only through patience is there time for every person to speak his piece, for every Board member to appreciate other viewpoints and for the "big picture" to sink in.

The virtue of patience is rewarded in lasting agreements that succeed because they have been thoughtfully composed—not rammed through—and have the committment of their constituents because they all agreed to it.

Cooperation

In Board operations, the consensus approach removes antagonism because nobody trys to force an issue with a split vote. This reduces tension among members and promotes an overall sense of cooperation. Over the years, this has built to such a level in our Board that it often forgets to vote on a decision unless reminded that it must keep some record of all the things that were agreed upon. In fact, the Board was quite pleased when its one and only motion was defeated because it proved that it could actually *disagree* on something.

Cooperation also enhances understanding and respect, and our Board promotes cooperative projects such as biological sampling and harvest monitoring which provide valuable insights to both users and biologists who are involved with them.

Consensus at the International Level

The International Porcupine Caribou Board

In 1987, Canada and the United States signed a cooperative agreement on the conservation of the Porcupine Caribou Herd. The agreement is administered by the International Porcupine Caribou Board which consists of four members from each country. The Board advises governments on matters pertaining to international co-operation and coordination in management of the Porcupine Caribou Herd. This Board also operates on the principle of consensus.

Achieving consensus at this level, however, is no easy matter. But so far the Board has succeeded in formalizing a technical committee to facilitate research coordination. And subsequently the Board directed this committee to prepare a report on sensitive habitats of the Porcupine Caribou Herd. The Board has also begun work on an international management plan.

Oil Development in the Arctic National Wildlife Refuge

Perhaps the greatest threat the Porcupine Caribou Herd will ever face is oil development on its calving grounds in Alaska's Arctic National Wildlife Refuge. Ironically, this is a case where consensus is out of the question because the arena where this is being played out, (i.e., the U.S. Congress) goes by different rules. In this arena, the two sides—developers and conservationists—are not working together to reach a decision. Rather, they are presenting their cases to a third party—the American public—which will give the final verdict. This is the democratic system which, as Churchill said, "is the worst in the world, except for all the rest."

Well, on a national scale, Churchill may be right. But, given the right conditions, I believe that consensus is a better way to go.

Summary

The co-management of renewable resources is an attempt to put governments and native people on an equal footing with respect to managing wildlife. The most common approach is to create an advisory Board with equal native and non-native representation. Such Boards function best if they incorporate some of the native ways of working together. The most important of these is decision making by consensus. To succeed, this approach must be supported by relevant communication, considerable patience and sincere cooperation.

For the past five years, the Canadian Porcupine Caribou Management Board has operated very successfully under these guidelines. In particular, it has been effective in dealing with several controversial matters which may not have been resolved without the overriding principle of consensus.

Consensus management is time-consuming and laborious compared to other more confrontational methods. However, the consensus approach generates an atmosphere of respect and cooperation that can increase the system's efficiency in the long run. Consensus management does not suit every situation but it should be attempted wherever possible and it is particularly appropriate to the co-management realm.

Co-management of Wildlife in the Western Canadian Arctic: An Inuvialuit Perspective

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Introduction

There has been a system of cooperative management of renewable resources in the western Canadian Arctic since 1984. Cooperative management means that two or more parties share decision making responsibilities regarding the management of resources. In this case, Inuvialuit of the western Canadian Arctic and the Government of Canada share such responsibility.

The document binding these two parties is an aboriginal land claims settlement known as The Inuvialuit Final Agreement (IFA) 1984.

The IFA was signed on 5 June 1984, and became a constitutionally protected federal law under the *Western Arctic (Inuvialuit) Claims Settlement Act* 1984. The signatories were the Committee for Original Peoples Entitlement (COPE), representing the Inuvialuit; and the Government of Canada, representing all the citizens of Canada, among them the Inuvialuit.

There are presently about 4,000 Inuvialuit—approximately 3,000 of whom live in the six Inuvialuit Settlement Region (ISR) communities of Aklavik, Inuvik, Tuktoyaktuk, Holman, Paulatuk and Sachs Harbour. The ISR contains Crown lands and offshore waters as well as 35,000 square miles of private Inuvialuit land.

The residents of Sachs Harbour, Holman and Paulatuk lead a traditional lifestyle centered around subsistence hunting, fishing and trapping. In the MacKenzie River delta, many Inuvialuit are wage-earners, although virtually all such Inuvialuit continue to hunt, fish and trap in addition to their employment. This subsistence harvesting is a vital and fundamental part of the Inuvialuit lifestyle and culture.

The Inuvialuit believe that the future well-being of the land and its wildlife are inseparable from their own. They were, therefore, instrumental in the creation of two parallel management structures under the IFA. The Inuvialuit Game Council (IGC) is concerned with renewable resources while the Inuvialuit Regional Corporation (IRC), is responsible for all other Inuvialuit interests, including administration of private lands, enrolment of beneficiaries, business interests and the implementation of social programs. The IGC is composed of representatives from each of the six community Hunters and Trappers Committees (HTCs) in the ISR. The HTCs are responsible for dealing with wildlife issues at the local level. The IGC thereby represents the collective Inuvialuit interest in all matters relating to wildlife.

Co-management Negotiations

During the negotiations of the IFA, the Government of Canada took the position, on constitutional grounds, that the ownership of wildlife must be maintained by the Crown and that ultimate authority for fish and wildlife management would remain with the minister of the appropriate government department. The Inuvialuit insisted that they be meaningfully involved in all decision-making processes dealing with the management of land and wildlife. Those negotiating the IFA resolved the issue by creating a mechanism whereby Inuvialuit management advice would be incorporated into the ministerial decision process. The result was the creation of five joint management bodies, collectively referred to as the Renewable Resources Committees. These committees deal with all aspects of resource management in the ISR, and it is through these committees that the IGC interacts with governmental management bodies. These cooperative management bodies are:

1. the Fisheries Joint Management Committee (FJMC);
2. the Wildlife Management Advisory Council, Northwest Territories (WMAC NWT);
3. the Wildlife Management Advisory Council, North Slope (WMAC NS);
4. the Environmental Impact Screening Committee (EISC); and
5. the Environmental Impact Review Board (EIRB).

Each body is made up equally of Inuvialuit and government members. Inuvialuit members are appointed by the IGC and the government members by Canada, or in the case of the territorial members by the appropriate territorial government with the consent of Canada. Each body has an impartial chairman who must be mutually acceptable to the Inuvialuit and Canada and plays an impartial role.

The bodies meet to discuss management issues in the ISR approximately six times a year. For the most part the meetings are held in Inuvik because of its central location in the ISR, although some meetings are held in other locations either in or outside of the ISR as necessity requires.

Six Years of Co-management

In the six years that the IGC and the joint bodies have operated, co-management of resources between Inuvialuit and government has been successfully developed and implemented. While this system of co-management is still evolving, the co-management bodies have already produced several significant management plans and components of wildlife legislation. Four examples are detailed in this paper.

Grizzly Bear Harvest

In 1988, the establishment of a harvest quota for grizzly bear (*Urus arctos horribilis*) was initiated in the ISR, and for the first time in Canada, a native organization (and user group) enacted wildlife regulations enforceable under government statutes.

Several years ago, the Tuktoyaktuk HTC raised the concern that grizzly bears were being over-harvested in the Tuktoyaktuk region. To correct this problem they suggested that a quota system be put in place.

This posed a unique problem for both the Inuvialuit and the government. Within the Settlement Region the Inuvialuit have preferential or exclusive harvesting rights to various species. These harvesting rights are subject to the laws of general application pertaining only to conservation and public safety. A "preferential right to harvest" means that if a species population is capable of sustaining a harvest, the quota will be alloted to the Inuvialuit first. If the needs of the Inuvialuit do not exceed this harvestable quota then the remaining portion of the quota will be alloted to non-Inuvialuit. "Exclusive harvesting rights" means that all of a harvestable quota will be alloted to the Inuvialuit, although the Inuvialuit may transfer some of these exclusive rights to non-Inuvialuit. Grizzly bear are a species to which the Inuvialuit have exclusive rights.

The IFA requires cooperation between government, the joint bodies, the IGC and the HTCs to determine and establish harvest quotas. These activities are no longer the sole jurisdiction of government management agencies. Therefore, when the Tuktoyaktuk HTC passed on their concern to the IGC, the IGC referred the matter to the WMAC (NWT). The WMAC (NWT) reviewed the proposals of both the Inuvialuit and the GNWT Department of Renewable Resources concerning the size of the harvesting area and the desirable sustainable harvest quota. With the WMAC (NWT) acting as a facilitator, consultations occurred between the government and the Inuvialuit until a consensus was reached. The WMAC (NWT) then made its recommendation to the Minister of Renewable Resources, who accepted them.

It, therefore, became the responsibility of the IGC to designate the hunting area and quota recommended by the Minister. Once this was accomplished (IGC 1989), the Tuktoyaktuk HTC drafted and passed a bylaw, with the assistance of the Territorial Justice Department, that set out the terms under which grizzly bear could be taken. These terms included designation of appropriate hunting areas, setting of times and dates in which harvesting would be permitted, details related to the protection of females and cubs, and guidelines for the collection of biological samples. The IGC approved the bylaw (IGC 1990), making it applicable to all Inuvialuit. Concurrently, the government of the N.W.T. adopted the bylaw as a regulation under the *Wildlife Act* (J. Bailey personal communication), making it enforceable by Wildlife Officers as anticipated under section 14(77) of the IFA. At the same time, the government passed a regulation under the *Wildlife Act* (J. Bailey, personal communication) which was virtually identical to the HTC bylaw, making its terms enforceable as general law to non-Inuvialuit.

At all times the WMAC (NWT) provided a forum for the government and the Inuvialuit to interact. The final result was a long-term management plan for grizzly bear and a potential economic benefit for Inuvialuit through guided sports hunting of this species.

Beaufort Sea Beluga Management Plan

The Beluga Management Plan (FJMC 1991) was jointly developed by Canada and the Inuvialuit. The Plan deals with management of beluga whales (*Delphinapterus leucas*) found each summer within the ISR. These whales form part of a larger population that over-winters in the Bering Sea. Each spring the population separates into several stocks that migrate into summering areas ranging from Bristol Bay on Alaska's west coast to the eastern Beaufort Sea. During the summer a portion of the

Beaufort stock concentrates in the MacKenzie River estuary. It is in this area that the Inuvialuit have hunted the beluga for generations.

Until the IFA was signed, beluga management in the Canadian Beaufort Sea was carried out through a variety of federal acts and regulations. However, the co-management provisions of the IFA required that changes be made to such laws to accommodate co-management. Consequently, the FJMC, with the assistance of the HTC's of Aklavik, Inuvik and Tuktoyaktuk, conducted extensive consultations in the MacKenzie Delta communities with Inuvialuit whale hunters and their families. The information gained from this allowed the FJMC to formulate two goals: to maintain a thriving population of beluga in the Beaufort Sea; and to provide for optimal harvest of beluga by Inuvialuit. To accomplish these goals the plan addresses: (a) determination of sustainable harvest levels; (b) conservation and protection guidelines for development activities (note: tourism is considered to be a development as defined in the IFA); (c) development of bylaws, regulations and a mechanism for enforcement; and (d) guidelines on research and monitoring of public education. Parts of the plan will require the development of bylaws by the HTCs. Some of these bylaws may be similar to those put in place to regulate grizzly bear quotas, and in such case would be enforced by officers of the Federal Department of Fisheries and Oceans.

In addition to these goals, the plan recommends that the continued exchange of information be maintained between the resource users in Canada and the United States, and that development of an international joint management agreement to ensure that the shared beluga stock is managed and protected throughout its range be pursued. The FJMC has recently initiated work on this agreement with the Inupiat of Alaska.

The Beaufort Sea Beluga Management Plan is in its infancy. Because of the extensive involvement of users and managers in its development, it is expected that implementation time will be short and that there will be few modifications required.

Polar Bears

The Polar Bear Management Agreement for the Southern Beaufort Sea (IGC and NSB 1988) is an international agreement between the Inuvialuit and the Inupiat of Alaska. It was developed pursuant to Articles 2 and 7 of the International Agreement on the Conservation of Polar Bears and Their Habitat (1976).

The range of this sub-population of polar bears (*Ursus maritimus*) in the southern Beaufort Sea extends from Icy Cape in Alaska to Baillie Islands in the N.W.T., thereby crossing the international boundary between Canada and the U.S.A. As the major users of this resource, the Inupiat and the Inuvialuit recognize their unique position to benefit from its management. With the assistance of the WMAC and the United States Fish and Wildlife Service, these two user groups have cooperatively developed the management agreement.

The agreement's primary objective is the maintenance of a healthy and viable population of polar bears in perpetuity. It accomplishes this through:

(a) enactment of hunting regulations to maximize protection of female bears and cubs; and
(b) collection of data on all polar bear harvests.

Other objectives include the minimization of the detrimental effects of human activities, particularly industrial activities, on polar bear habitat, and the encouragement of the wise use of polar bear products and by-products. Efforts to obtain legislative changes are integral to satisfy these objectives.

In recognition of this agreement, the United States Fish and Wildlife Service officially commended the IGC and the North Slope Borough Fish and Game Management Committee and presented them with an award for their efforts.

Inuvialuit Renewable Resource Conservation Management Plan

This plan, (WMAC and FJMC 1988) defines the direction and intent of the previous management plans and agreements mentioned. It was cooperatively developed by the WMAC (NWT) and the FJMC, and endorsed by the IGC and the government agencies represented on the co-management committees. It forms the blueprint for implementation of the requirements and recommendations arising from the IFA and the report of the Task Force on Northern Conservation (1984). The plan's principles and goals are an excellent example of what co-management should be: traditional stewardship of the land, expressed in contemporary terminology.

The plan sets out a long term strategy for renewable resource conservation and management, and includes guidelines for future use of renewable resources within the ISR. To ensure that the wishes of the people most affected are fully taken into account, the plan states as a first priority that local community plans will be developed within the overall plan to highlight local goals and priorities. One such plan has been developed for Paulatuk (WMAC 1990), and another is under way for Tuktoyaktuk. The other four community plans will be finalized in the next two years.

The Inuvialuit believe that this approach is consistent with the philosophy of the people, for whom the fish, wildlife and other renewable resources are the keys to much of their future.

Conclusion

Based on the examples set out above, it has been shown that co-managment of renewable resources allows the Inuvialuit to play a meaningful role while still continuing to benefit from government management expertise. Co-management has been proven to be a system that works for the benefit of Inuvialuit, the land and its wildlife.

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The Yukon Fish and Wildlife Management Board: Its Evolution and Future

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Introduction

First, let me give you some information about myself. I am one of twelve members currently serving on the Yukon Fish and Wildlife Management Board, and have done so since its inception. Previously, I served on the old Wildlife Advisory Committee of which we will be speaking more. I also am one of the Yukon delegates to the ongoing Yukon River negotiations attempting to complete the Canada/United States Pacific Salmon Treaty. I am a professional realtor and also the pastor at the United Pentecostal Church in Whitehorse. My family and I have enjoyed living in the Yukon since 1971.

History

About 1978, an idea began to circulate and be talked about in the Yukon that was to have far-reaching implications for the management of wildlife there. People were beginning to look at the somewhat ''taken for granted'' resource of fish and game from a new perspective. It was becoming apparent to more and more people that our fish and our wildlife—our wilderness—was a much more valuable entity than they had previously realized. They were becoming more concerned about entrusting such a precious commodity to government technocrats and in particular to bureaucrats, and began in a very unorganized way to appeal for opportunity, to be involved in the management of this resource. I use the term unorganized because I want you to understand clearly that there was not an intensive lobbying effort to create such opportunity but rather there was a ''feeling'' developed among hunters, fisherman, naturalists and others that unless they got involved, this wonderful resource would go the way of other jurisdictions and be lost forever.

People talked about it in coffee shops, on the street, at club and association meetings, and eventually the message filtered through to the government and a new body was formed.

The Wildlife Advisory Committee

In 1982, the government created the Wildlife Advisory Committee. It consisted initially of six members, chosen by special interest groups, and brought together by the Minister of Renewable Resources on an irregular basis to meet with him or his designate. Its primary purpose was that of a sounding board, to sort of ''test the waters'' in regards to policies, directions, and contemplated initiatives of the government. The Committee was not responsible as a whole, but individual members felt enormous responsibility to the interest group they were representing. The Outfitter's representative, for instance, felt compelled to protect his industry at all cost while the Conservation Society member worked in the same way. Each representative was duty-bound and expected to report to his or her respective constituency. They were individually accountable to "their group."

The minister, on the other hand, was in no way accountable to the Committee. All deliberations were in camera, all information and discussions were confidential unless specifically declared public information, and often recommendations were either ignored or contravened.

The lack of a unifying mandate and no ministerial accountability caused much frustration and resentment in the Committee. It became apparent though, that there was an even greater problem—Where was the Indian representative from among the people of the Yukon First Nations? The experience, wisdom and insight of native peoples was not being utilized and members of the committee felt that should change. During one of the last meetings of the Wildlife Advisory Committee it was suggested to the Minister of the day, David Porter, that equal representation for Yukon First Nations on the committee be pursued. This was to be no easy task. Yukon First Nations people had observed wildlife management by others in the Yukon for decades, much of it contrary to their views and almost always without their consultation. At much the same time that the Wildlife Advisory Committee was reaching the end of its road, Yukon Indian people were negotiating with the Yukon and Federal governments for new framework for managing wildlife. The features of this proposed new arrangement were outlined in a "Sub-Agreement on Fish and Wildlife Conservation and Use," which was initialed by Land Claims Negotiators on October 5, 1988. This subagreement is now part of the Yukon Indian land claim Umbrella Final Agreement. The centerpiece of the Wildlife Sub-Agreement is a 12-member Fish and Wildlife Management Board.

In November 1988, David Porter, the Yukon Renewable Resources Minister, decided that it was time to attempt to demonstrate the benefits of cooperative wildlife management.

The Yukon Wildlife Management Board

Six people from Yukon First Nations and six from the non-aboriginal community were appointed by the minister to serve on the Yukon Wildlife Management Board. They were chosen at large, selected on their own merits as members of their community. Most importantly, they were not representatives of special interest groups. They came with their own personal credentials from communities throughout the Yukon, and with a wide range of Yukon interests. Women were represented, hunting, trapping, outfitting and guiding backgrounds were evident, as were non-consumptive user interests. The idea was to conform with the intent of the Wildlife Sub-Agreement to have 50 percent First Nations representation on the Board and pre-implement the cooperative management approach called for in the Agreement.

The major difference from the earlier Wildlife Advisory Committee however, was the issue of ministerial accountability to the board. The minister would seek the board's recommendations on fish and wildlife policy, programs, legislation, and management, but would now be responsible to report to the board, in writing, as to his decisions. In the event he decided not to implement a board recommendation, he was obliged to give his reasons, again in writing, within sixty days. Ultimate responsibility rested with the Minister but he was clearly publicly accountable. Board minutes and recommendations became matters of public record as did the decisions of the minister. Aboriginal people finally had a formal and major role in the management of wildlife.

The Board has a formidable track record. In its two and a half years of operation, some 53 recommendations have gone to the minister. All have been implemented except one that was modified. All but three were arrived at by consensus.

In 1990, the Government of the Yukon negotiated a transfer of Yukon freshwater fisheries management responsibilities from the Federal Department of Fisheries and Oceans, and the Board became known by its current name.

The Yukon Fish and Wildlife Management Board

Despite its accomplishments, the Board has had some persistent difficulties, all of which seem to have a common thread. It has been very difficult to dispel the notion that the Board is a government agency. I must emphasize how difficult it has been to try to shake this image. Yukon First Nations remember years of neglect and abuse while non-aboriginal people have vivid recollections of little being accomplished by the old Wildlife Advisory Committee. The Board is acutely aware of this problem and is actively working to raise its profile and identity as a public board.

The terms of reference for the Board call for providing the minister with recommendations on all matters pertaining to fish and wildlife programs, policies, and legislation. Additionally, given the migratory nature of some species, the Board has the responsibility of making recommendations and interventions with respect to those species and their habitat. This external affairs aspect of our responsibility is currently being exercised with respect to the pending protocol to amend the Canada/U.S. Migratory Bird Treaty.

The Board is headed by two co-chairs, one aboriginal and one non-aboriginal, who serve consecutive one year terms. These individuals are chosen from within the board, by the board as a whole. This approach was taken informally by the Board to reinforce the cooperative nature of its business and is working well to date. Terms of office for all board members have been two years.

Perhaps the most outstanding development in the board's growth has been an insistence that management decisions must not be made without input from what we refer to as ''traditional knowledge''—people living on the land are recognized as a very important, indeed absolutely necessary, source of critical information. Often, proposed management initiatives or regulation changes have been modified or controverted because of information received from native elders, trappers and fishermen.

Secondly, there has been a very marked change in the attitude towards non-consumptive use of wildlife. The idea that our land is useful only as a ''protein factory'' is quickly changing. Almost every decision taken by the Board is now tempered by consideration of non-consumptive values and implications.

The Future

The Yukon First Nations people have not yet formally nominated their representatives to the Board, but rather have given assent to its operation and ratified the members appointed by the Minister. The Umbrella Final Agreement calls for six members of the Board to be appointed by Yukon First Nations and six members to be appointed by government. This will be a great step towards truly cooperative wildlife management.

Almost all the business conducted by the Board thus far has been reactive in nature. Although it holds public meetings several times a year, most of its time has been devoted to proposals coming from within the government. This, no doubt, is part of the reason it has been so difficult to dispel its "government" image. The Board will have to become far more proactive in nature and is taking steps to do so. Personal initiatives by Board members, more frequent public meetings away from Whitehorse our capital city, and an aggressive media campaign to bring the message that "this is your Board" has been determined to be of paramount importance by all Board members. The Board is now holding special sessions to develop strategies to achieve this objective.

An independent secretariat is now in place, the importance of which cannot be over-emphasized. The term of service for Board members is expected to be five years and arranged in such a way as to ensure continuity.

The preservation and enhancement of habitat, as well as rebuilding fish and wildlife populations, will be one of the major roles of the Board in the future. The Board will be able to make significant contributions to this end through its administration of a $3-million Trust Fund established with the completion of Yukon Land Claims. The Board will have sole responsibility for the disbursement of interest generated by this fund.

There is a very strong sense developing on the Board that the existence of a wilderness in years to come will be of highest value in the Yukon—far above all other fiscal and developmental considerations.

Conclusion

The building of the Alaska Highway in 1942 drastically altered the demographics of the Yukon. The population of Whitehorse grew from around 600 to over 20,000. Once the War was over, things subsided but the Yukon would never be the same. The now predominately non-aboriginal population wanted, and took, access to the resources of the Yukon. Little thought was given to the impact this was having on the aboriginal people or their land. The abuse and neglect of them and their resources are a matter of record. The patience of the aboriginal people of the Yukon is a testimony to them as a truly great people. We are only now beginning to recognize the critical role they must have in the future of wildlife management in our beautiful land.

The Yukon Fish and Wildlife Management Board is different from boards in the Northwest Territories, composed primarily of native and government members, neither is it on the order of the Alaska fish and wildlife commissions. It is a unique structure of aboriginal and non-aboriginal people working together for the common good of both. The Yukon is approximately 70 percent the size of the great state of Texas, yet less then 35,000 people live there. Statistically, there is a hunter in every household, one in four people have a hunting license, and even more fish. The use of fish and wildlife is a matter of highest priority and let me assure you, Yukon people are anything but apathetic. The preservation of our most important resources—

our land, our water, our fish and our game—our wilderness, has become the Board's one unifying mandate.

This bring me to perhaps the most important observation, not only mine, but many others. The conduct of the Board has been remarkably free of political overtones. Because of the common desire by all members to "do what is right" to protect our wilderness, there has been virtually no polarization, no "us against them" mindset has arisen to date. Indeed the operations of the Board have been guided by a powerful unity of purpose that is spiritual in nature.

It may be that the greatest achievement of the Yukon Fish and Wildlife Management Board in the future will be the healing of our people as well as our land.

Polar Bear Management in the Southern Beaufort Sea: An Agreement between the Inuvialuit Game Council and North Slope Borough Fish and Game Committee

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Introduction

Polar bear (*Ursus maritimus*) occupying the arctic pack ice of Alaska and Canada represent an important local and international resource. The significance of polar bear to Canadian Inuit and Alaskan Inupiat hunters is quite different and more complex than is the importance of polar bears to the general public. To indigenous peoples, the polar bear represents both tangible and intangible values. Polar bear meat is a desired source of protein in regions where the cost of domestic meat or protein sources is extremely expensive. Polar bear fur may be crafted into warm mittens, ruffs or other clothing for use in the harsh environments. Polar bear may provide a source of income from the sale of the handicrafts. In Canada, hides may be sold at auction and Inuit hunters may guide a limited number of recreational hunters. A special status or prowess is attributed to the hunter fortunate enough to harvest a bear. The cultural significance of polar bears is manifest in stories, legends and lessons which are passed on from generation to generation.

In Alaska, the U.S. Fish and Wildlife Service (FWS) is the agency with the authority to conserve and protect polar bear under provisions of the Marine Mammal Protection Act (Act). In Canada, the Canadian Wildlife Service and individual provincial and territorial jurisdictions are responsible for managing polar bear. The five circumpolar nation "Agreement on the Conservation of Polar Bear" reflects the international concern for the welfare of populations and the need for cooperation and coordination in conducting studies or managing shared populations. The best interest for the Beaufort Sea polar bear population is served at the local level when users and managers work cooperatively in the stewardship of this valuable resource. The concern of the Inupiat and Inuvialuit for the long-term welfare of polar bear populations provides the motivation to cooperate in the management and conservation of polar bears in the eastern Beaufort Sea region (Figure 1). This concern led to the development and implementation of the "Management Agreement for Polar Bears in the Southern Beaufort Sea," ratified in January 1988.

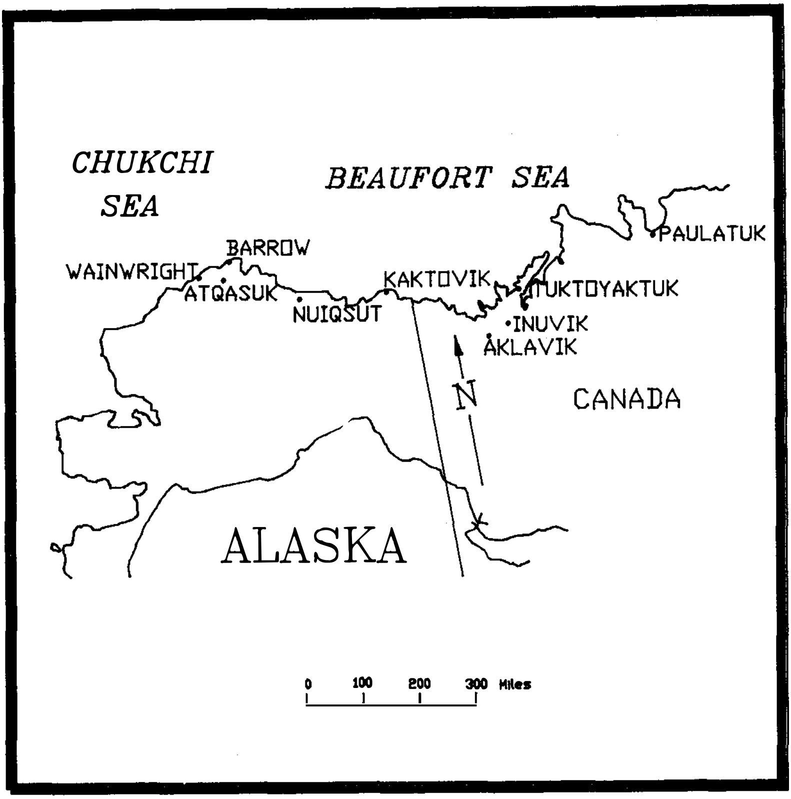

Figure 1. Alaska and Canada Beaufort Sea area.

Historical Harvest Accounts

Indigenous people of the arctic have harvested polar bear for many years. The methods, means, effectiveness and magnitude of this harvest has changed dramatically starting in the late 1800s when explorers and traders introduced firearms to the arctic. Previously, most polar bear were taken with spears and arrows and the use of dogs to bring the animal to bay. The number of bear taken during the pre-firearm period is unknown, but likely did not affect populations. Today, polar bear are taken with firearms of varying caliber. From 1925–1953 the average state-wide harvest of bears based on fur export records was 117 animals per year; while during the 1954–1960 period an average of 158 bears were harvested. During the later period, recreational hunting of polar bears by nonnatives and nonresidents was increasing. Alaska Department of Fish and Game information shows the average harvest for the 1960–1972 period was 260 bears of which an average of 63 (25 percent) were females.

The Act of 1972 shifted the management of polar bear from the State of Alaska to the FWS. The Act imposed a moratorium on the killing or "taking" of all marine mammals; this included the recreational harvest of polar bears by nonnatives. Specific exceptions allow the taking of marine mammals for valid scientific purposes, collection for public display and incidental take in commercial fishing. The Act also allowed coastal dwelling Alaska Natives to continue traditional harvest of marine mammals for subsistence or handicraft purposes. The harvest must be accomplished in a nonwasteful fashion from nondepleted populations.

Following passage of the Act, 1973–1979, the average annual polar bear harvest declined to 86 bears comprised of 37 (43 percent) females. From 1980–1988 FWS records indicate, the average harvest was 130 bears of which 47 (36 percent) were females. North Slope villages account for an average of 39 (39 percent) bears removed annually during this period. Following passage of the Act the percentage of the harvest comprised of females has increased, yet the net removal of females is less than for the 1960–1972 period. Further, the removal during the 1960–1972 period, by regulation and hunter preference, concentrated on larger adults and likely did not include dependent animals nor smaller subadult females to the degree of today's harvest.

In Canada since 1968, the annual harvest of polar bear has been regulated by a quota system. Following the 1978–1979 hunting season, the quota for the eastern Canadian Beaufort Sea was 97 bears, of which 38 were estimated to have come from the population shared between the U.S. and Canada. Communities which take bears from this stock include Aklavik, Inuvik, Tuktoyuktuk and a portion of the Paulutuk harvest. In Canada, a smaller number of tags are allocated annually to Inuit hunters to guide nonresident recreational hunters. This allocation increases the economic return per animal harvested above that obtained from the sale of hide alone. The tags from unsuccessful sports hunts may not be reused; this reduces the number of bears removed from the population. Canada requires that dog teams be used for transportation in guided hunts.

Results of Research Pertinent to the Agreement

Research in Alaska and Canada designed to answer questions concerning population status, trend and life history parameters began only as recently as the late 1960s. Much progress has occurred in the following years although many questions remain. One of the most important accomplishments, which can be directly traced to the development of this cooperative management agreement, is the development of technology which enabled the monitoring of polar bear movements across vast distances (Figure 2). In 1983, scientific evidence from satellite and conventional radio collars showed that the population of polar bear occupying the Southern Beaufort Sea from about Icy Cape in Alaska, to Baillie Islands in the Northwest Territories, Canada, was for management purposes a discrete and internationally shared population. Other biological information on population size, denning patterns and predator/prey relationships also began to emerge. The improved population data has increased the stewardship responsibility of users and managers to effect sound management decisions.

Mutual Concern Leads to Cooperative Proposal

Polar bear management concepts were first discussed informally at meetings of Canadian and Alaskan users of the Porcupine Caribou Herd. Recognizing the mutual

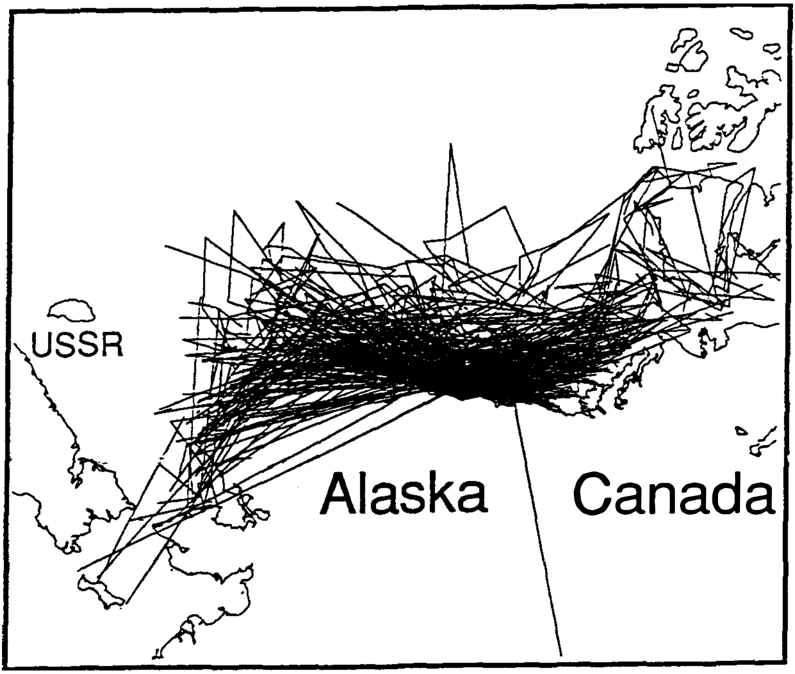

Figure 2. Movements of all Beaufort Sea polar bears followed by radiotelemetry during 1981 through 1988 (from S. C. Amstrup unpubl. data.).

concerns of Alaskan and Canadian users, fundamental similarities to the caribou management needs, the increasing biological evidence concerning the shared nature of the polar bears of the region and the stated intent of the International Agreement for the Conservation of Polar Bears, the respective local user groups, North Slope Borough Fish and Game Management Committee and Inuvialuit Game Council embarked upon a coordinated management approach. Biologists from the FWS and Canadian Wildlife Service were consulted and lent support to the concept of cooperative management offering to work with the respective groups as technical advisors in the development of a management plan or agreement.

The first formal meeting of the parties occurred in August 1985 in Barrow, Alaska, where concerns for the dissimilar management regimes were discussed. On April 4, 1986, the North Slope Borough's Fish and Game Management Committee passed resolution 86–01, Protection and Use of Polar Bears. On September 16, 1986, representatives from the Inuvialuit Game Council, Fish and Game Management Committee, and resource agency representatives developed and initialed a draft Memorandum of Understanding which served as a framework for the management of Beaufort Sea polar bear. The Memorandum of Understanding formed a Joint Commission, comprised of representatives of the user groups, and a technical committee, comprised of resource agency representatives, to develop a management agreement for polar bear in the Beaufort Sea. The principles and objectives of the agreement were specified. On November 6, 1986, by unanimous resolution, the Fish and Game Management Committee ratified the terms of the Memorandum of Understanding. On March 3, 1987, members of the Joint Commission and Technical Committee were appointed and a preliminary draft management agreement was advanced for review. After review, comment and modification by hunters from the affected villages, the Agreement was ratified by resolution. The "Polar Bear Management Agreement for the Southern Beaufort Sea" was signed during a January 1988 ceremony in Inuvik, Canada.

Terms and Conditions of the Agreement

The foundation of the Agreement is a desire by the users to protect the polar bear resource of the eastern Beaufort Sea and to assure that future management is based upon the best scientific information available. The Agreement creates a Joint Commission comprised of two representatives each, from the Inuvialuit Game Council and the Fish and Game Management Committee and also creates a Technical Committee to advise and report to the Joint Commission. The Technical Committee is comprised of federal, state and provincial agency personnel from Canada and Alaska knowledgeable of polar bear research and management activities in the region. The Technical Committee, in consultation with the Joint Commission, establishes the sustainable harvest level and reviews scientific information and harvest data to assess the need for modifications in annual allocations. The initial determination of sustainable yield occurred in October 1988. Based upon the population estimate of 2,000 bears for the Beaufort Sea region and an existing (2:1) male to female harvest sex ratio, the technical advisors indicated that the sustainable yield for the population is 76 animals. The Commissioners agreed to the figure and established an equal distribution of 38 animals each for the Canadian and Alaskan parties. Each party remains responsible for the allocation among their villages. Canada ascribes an individual village quota while Alaska maintains the entire block allocation available for harvest by affected villages as a group.

Terms of the Agreement provide for protection of cubs and their mothers, denning females, restriction on hunting seasons, allocation guidelines, prohibitions on the use of aircraft or large motorized vessels to take polar bears, stipulations for protection of the environment, and continued support for polar bear research and data acquisition. In Canada the Agreement is consistent with previously existing regulations. In Alaska the Agreement is more restrictive than the Act and thus is without federal regulatory authority. The Agreement terms which are more restrictive than the Act are enforced primarily by local sanction, peer influence and a desire by hunters to be responsible for their activity.

Results

During the initial harvest year, 1988–1989, Alaskan hunters exceeded the harvest guidelines by 20 bears (58); however, the take of the critical female component remained within sustainable limits (Table 1). The Canadian harvest (32) during this period remained below the allocation level. During the second year of the Agreement, 1989–1990, both the Alaskan (24) and Canadian (34) harvests were less than the allocation level set at 38 bears per party. The cooperative development of an informational poster and brochure stating the intention, conditions and terms of the Agreement, coupled with an extensive communications effort by personnel of the North Slope Borough, is believed to be responsible for the reduced take. The North Slope Borough recognizes and remains committed to the continuing effort necessary to implement conditions of the Agreement.

In Alaska during 1988–1989, 58 polar bears were harvested by residents of five communities. The harvest was distributed as follows: Kaktovik (10), Nuiqsut (2), Barrow (29), Atqasuk (2), and Wainwright (15) (Table 1). The harvest was 45 percent greater than the preceding five-year average. All villages excluding Wainwright exceeded the five-year average. The ratio of male to female bears was 0.85:1. Sex was unknown for 17 bears harvested during this period. The harvest of females occurred in the months of October (5) and November (1). Complete sex and age information was available for 41 percent (24/58) of harvested bears. An improvement in complete reporting of data from harvested bears is noted.

The harvest occurred in 9 of 12 months. One bear was taken in the summer outside of the prescribed season. Kaktovik, Nuiqsut and Atqasuk took 77 percent (10/13) of their harvest in October and November. Barrow and Wainwright harvested bears predominantly in the fall/early winter and later during spring whaling.

An important segment of the harvest, 40 percent (23/58), occurred during the spring whaling activities in May. Nuisance bears were present in whaling camps and hunter interviews indicate that at least five of the bears killed in May were taken due to the danger the bears presented. Furthermore, at least 66 percent (6/9) of the bears taken by hunters from Kaktovik during the fall were in or near the village and

Table 1. Polar bear harvest from the eastern Beaufort Sea, 1988–90.

	1988-89			1989–90			Total		
Alaska	Male	Female	Unknown	Male	Female	Unknown	Male	Female	Unknown
Alaska									
Kaktovik	5	2	3	1	—	—	6	2	3
Nuiqsut	2	—	—	—	2	—	—		
Barrow	18	1	10	10	4	1	28	5	11
Atqasuk	1	1	—	—	—	—	1	1	—
Wainwright	9	2	4	7	—	—	16	2	4
Industry				—	1	—	—	1	—
Subtotal	35	6	17	18	5	1	53	11	18
Canada									
Aklavik	3	1	1	—	2	1	3	3	2
Inuvik	—	—	—	—	1	—	—	1	—
Tuktoyuktuk	15	5	1	15	9	1	30	14	2
Paulatuk[a]	4	2	—	2	2	—	6	4	—
Subtotal	22	8	2	17	14	2	39	22	4
Grand total	57	14	19	35	19	3	92	33	22

[a]The Paulatuk harvest is one-third of the annual village harvest. Tag returns of bears captured and marked by researchers indicate that one-third of the harvest is comprised of Beaufort Sea stock animals. Sex ratios are proportionate to the annual sex ratio of the total take.

may have presented a hazard to residents. Wainwright hunters harvested a bear in the village in October. The Agreement recognizes that bears may be a problem at any time of the year and authorizes harvests outside the prescribed season if required for personal safety.

Although the harvest during October accounted for 26 percent of the take, the harvest was far below the availability of bears. Bears were abundantly available on or near shore from Kaktovik to Wainwright during this period. Thus, we believe a substantial effort was made by hunters during the fall to avoid taking bears.

During the second year of the Agreement, 1989–1990, North Slope Borough hunters from three villages harvested 24 bears, including one bear taken in a defense of life situation by an industrial oil-field worker. Additionally, one bear was taken by a nonnative in Barrow for public safety and one bear was killed in the village of Wainwright following repeated visits. The harvest was distributed between the following villages—Kaktovik (1), Barrow (15), Wainwright (7) and industry (1). All villages harvested fewer bears than their five-year average, and the villages of Nuiqsut and Atqasuk did not harvest bears during the period. The ratio of male to female bears identified on sealing forms was 0.83:1. Sex was unknown for one bear. Complete sex and age information was available for 52 percent (13/25) of harvested bears.

The harvest occurred in 9 of 12 months. Two bears were harvested outside the prescribed season. The harvest was evenly dispersed throughout the year and only May accounted for a large percentage of the take, 29 percent (6/21). Five bears (one female) were taken during the October and November period which coincides with normal denning activity.

Future of the Agreement

The North Slope Borough is encouraged by the successes of the initial two years of the Agreement. Although areas requiring improvement have been detected, we believe that through a strong and continuing commitment to the terms of the Agreement continued progress can be achieved. It is our hope that the conservation ethic contained within the terms of the Agreement becomes engrained into the hunting communities of the North Slope. We recognize that in many instances progress requires time, patience and effort in order to achieve long-lasting gains. Our goal is to continue the cooperative working relationships with the resource agencies in order to realize these gains.

Subsistence Harvesting of Waterfowl in Northern Quebec: Goose Hunting and the James Bay Cree

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Introduction

James Bay represents a critical staging area for several eastern North American stocks of Canada geese (*Branta canadensis*), brant (*B. bernicla*) and lesser snow geese (*Anser caerulescens caerulescens*) (Thomas 1982). Important expanses of subarctic salt marsh, eelgrass meadows and berry-rich heathland (Dignard et al. in press) provide a rich food base allowing the geese to replenish energy reserves for continued migration, whether it be to breeding areas further north in Ungava and Foxe Basin during spring or to mid-Atlantic and Mississippi Valley wintering grounds in the U.S.A. during fall. In spring, the geese store additional quantities of nutrients in preparation for the approaching breeding season (Thomas 1982, Wypkema and Ankney 1979).

A number of Cree settlements are scattered along the coasts of James Bay, many inhabitants of which still rely heavily on wild geese and other game for subsistence (Hanson and Gagnon 1964, Boyd 1977, Berkes 1982, James Bay and Northern Quebec Harvesting Research Committee [JBNQHRC] 1982, Prevett et al. 1983). Until the JBNQHRC (1982) report was published, little was known about the number of geese of each species taken by Cree, when and at what locations, and what impact this kill might have on the different stocks. The announcement in the early 1970s of intentions to construct a series of hydroelectric dams along rivers flowing into the Quebec (east) coast of James Bay brought a flurry of wildlife and anthropological studies and led to a major land claims settlement, the James Bay and Northern Quebec Agreement in 1975.

This report summarizes recent information on the Cree goose hunt along the Quebec coast of James Bay. That hunt is examined in relation to its importance in the continental scheme of waterfowl management as well as its significance to the socio-economic well-being of the indigenous population. Cree methods of regulating the hunt and managing goose populations and their habitats are also discussed. The need for closer cooperation between native hunters and government management agencies is outlined and recommendations made to meet that requirement.

The Goose Stocks

Examination of the banding origins of Canada Geese recovered near the east coast of James Bay indicated that more than 90 percent were associated with the Mid-Atlantic Population (Reed 1984) which breeds in northern Quebec and Labrador and winters essentially in the Delmarva Peninsula (Bellrose 1980, Hindman and Ferrigno 1990). The same band recovery information indicated small numbers associated with the Southern James Bay Population (formerly the Tennessee Valley Population) and the Mississippi Valley Population (Reed 1984). Many of the spring migrating Canada geese are destined for nesting areas further north on the Ungava Peninsula, but appreciable numbers breed nearby within the Cree territory.

All or most of the brant which migrate through James Bay overwinter along the Atlantic Coast between Massachusetts and North Carolina; they breed principally on Southampton Island and along the coasts and islands of Foxe Basin (Reed et al. 1987).

About 90 percent of the lesser snow geese which migrate along the east coast of James Bay originate from colonies on southwestern Baffin Island, the remainder from at least five other colonies on Southampton Island and along the western and southern coasts of Hudson Bay (Reed 1984, Boyd et al. 1982, Dzubin et al. 1975). They are destined for wintering areas in both the Mississippi and Central Flyways.

Characteristics of the Cree Goose Harvest

From 1972–73 to 1978–79 a detailed study was conducted of the kill of waterfowl and other game by hunters of all five coastal and three inland Cree settlements in Quebec (JBNQHRC 1982). The average annual kill of the three goose species is shown in Table 1. Of the 90,200 geese shot annually, Canada geese were most abundant in all but one settlement, the most southerly coastal site at which snow geese outnumbered all others. Almost 95 percent of the brant were taken in two coastal communities. Of the total annual Cree kill of Canada geese, 58 percent occurred in spring and 42 percent in fall; equivalent proportions for the brant kill were 31 percent:69 percent and 13 percent:87 percent for snow geese (JBNQHRC 1982).

The Socio-economic Significance of the Cree Hunt

The goose harvest brings in approximately 200,000 kg of edible meat annually, or about 25 percent of the total consumption of wild animal food; its replacement value in store-bought food for a typical family of six would be about $6000 (Scott 1987).

Geese, especially Canada geese, are held in high esteem by Cree society. Local school schedules are adjusted to allow children to accompany their parents to their traditional camps for the spring and fall goose hunts. These gatherings are "an annual renewal of the relationship between the Cree and the geese, a promise of abundance collectively shared, and the occasion for high-spirited celebration . . . The killing, sharing and consumption of game is central to the seasonal renewal of social relations

Table 1. Mean annual kill of geese by Cree hunters in the James Bay area, Quebec, 1972–73 to 1978–79 (from JBNQHRC 1982).

Location	Canada geese	Brant	Lesser snow geese
Coastal	57,680	6,290	20,380
Inland	5,460	130	260
Total	63,140	6,420	20,640

in Cree villages, and of a relationship to the land which is both secular and sacred in importance.'' (Scott 1987).

The Organization, Structure and Regulation of the Cree Hunt

The Cree goose hunt is a structured communal activity, based on traditional knowledge and strategies, and subjected to local rules and regulations. It has been described in some detail by Berkes (1982) and Scott (1987); the following summary is based largely on their descriptions.

The coastline is subdivided into several hunting territories, each belonging to a few families. An experienced hunter (the goose boss) has the responsibility of directing and controlling the hunt in the territory. He decides who may hunt on the territory, and determines, on a daily basis, where the hunt will occur and how it will be conducted. Other experienced hunters often participate in the decision making process. A number of general rules prevail. There is no hunting on Sundays, and before dawn or after dusk on other days. To limit disturbance of resting geese, hunting is conducted well downwind from major flocks and is avoided on calm days. Prime feeding areas are left unhunted for several days on end, and never hunted in a way that would frighten off a major flock. Other hunting sites are used in rotation so that on any given day only one or two sites are hunted and all others are available for undisturbed use by the geese. Traditional rules and day-by-day decisions are based on an extensive body of ecological knowledge, passed on from generation to generation but continually evolving from new information and experience (Berkes 1982, Scott 1987).

These and other traditional practices ensure the availability of geese for a sustained harvest, at the same time allowing the geese access to critical feeding and resting areas. Essentially, this system differs only in detail from southern practices of refuging and harvesting geese.

Habitat Management by the Cree

For many generations Cree hunters have constructed small ponds along the coast to attract spring migrating Canada geese. Rudimentary dikes were built of boulders and sod to hold back early spring run-off from small salt marsh streams to create small bodies of open water at a time when other wetlands were still ice-chocked. Although used principally as spring hunting sites by the Cree, the ponds often supported relatively lush wetland communities which provided additional food for geese and other migratory birds. Since the mid 1980s the Cree have solicited technical help from the James Bay Energy Corporation (JBEC—a branch of Hydro-Quebec) to expand and improve pond construction along the northeast coast of the bay. The program is largely experimental because there is little scientific information available on the manipulation of subarctic wetlands. The Cree are seeking more than open water for hunting; they are placing emphasis on creating high quality wetland habitat which will provide additional food resources for migratory waterfowl. They are actively cooperating with the JBEC and the Canadian Wildlife Service in a Canada goose food study aimed at identifying key plant species which could be used to enhance the value of the ponds (Reed et al. 1990). Also, in recent years, the Cree have undertaken shrub clearing projects to slow down the invasion of certain salt marshes and fens by willows.

The Impact of the Cree Hunt on Continental Goose Stocks

Using band recovery information and harvest survey results, Reed (1984) estimated that during the 1970s the Quebec Cree harvest made up 13 percent of the total hunting kill of Mid-Atlantic Canada geese and 4 percent of the eastern Canadian arctic lesser snow goose kill (Table 2). Calculations for brant were complicated by closure of the recreational hunting season and voluntary reduction of the subsistence hunt following severe winter die-offs in 1976–77; an estimate, based on the short run of years available (1973–74 to 1976–77), suggested that the Quebec Cree took 22 percent of the harvest, U.S. Atlantic Flyway hunters took 73 percent, and other users 5 percent (Reed 1984).

The take of Canada geese and brant by Quebec Cree must clearly be taken into account for population management of those stocks. But these relatively large kills should not be seen as a new factor which emerged in the last decade or so; Cree subsistence harvests of this magnitude have undoubtedly occurred for many decades and the impact of them unknowingly reflected in the annual assessments of population size each winter.

The Need for Cooperative Management

It should be clear from the above that both the Cree hunters and government wildlife agencies have vested interests in the goose stocks which migrate through James Bay. Each group has a distinct set of exploitation needs, management practices and a supporting body of ecological knowledge. But they share the overriding common requirement of managing the goose stocks to ensure sustained use.

Each party can benefit enormously from the other's experience and knowledge. Wildlife biologists can bring a valuable quantitative dimension to the understanding of goose ecology and population dynamics, and transmit useful information on flyway-wide management concerns which are otherwise unavailable to the Cree. The Cree's intimate knowledge of the land and the geese can provide answers to many management questions or, at the very least, provide a sound background for planning

Table 2. Approximate distribution of the annual kill of Mid-Atlantic Canada geese and eastern Canadian arctic lesser snow geese during the 1970s (from Reed 1984).

	Average annual kill (percentage of total)	
Region	Canada geese	Lesser snow geese
James Bay, Quebec Cree	63,140 (13.3)	20,640 (3.6)
Elsewhere in northern Quebec and Northwest Territories	32,340 (6.8)	18,810 (3.3)
Elsewhere in Canada	51,730 (10.9)	130,520 (23.1)
U.S. Flyways	328,880 (69.1)	395,580 (69.9)
Total	476,090	565,550

and implementing scientific studies. With such an important base of common ground, and with the goose populations generally flourishing, the opportunities for developing cooperative management programs appear excellent.

Although several joint programs initiated since the early 1970s have been successful (the native harvest survey [JBNQHRC 1982] being the best example), progress has been disappointingly slow. Government sponsored wildlife research and surveys have been hampered by the high costs of operations in remote northern areas, by the legal and practical requirement to consult with the native landholders, and by difficulties in integrating native concerns. Of particular difficulty is the establishment of long-lasting links of communication between wildlife researchers and the Cree community. But such links are essential in bridging cultural gaps and establishing a spirit of mutual trust and understanding, without which little progress can be made.

What Does the Future Hold?

Recently announced expansion of hydroelectric development in James Bay (Gorrie 1990) has revived public and political interest regarding ecological matters and native concerns in the area. On a broader geographical scale, additional land claims and other legislation are likely to strengthen native harvesting rights and to give increased decisional powers to indigenous groups (Stirling 1990). Even the geese themselves have become the subject of revigorated scientific interest through the recent establishment of the Arctic Goose Joint Venture (an offshoot of the North American Waterfowl Management Plan) to coordinate and facilitate ecological study of arctic nesting geese. It is likely that there will be greater opportunities to conduct essential studies of geese, their habitats and their users in James Bay through the 1990s. To gain complete benefit of those opportunities, every effort should be made to encourage full native participation. As Stirling (1990) remarked "The unique knowledge and cultural practices of northern native people must be kept intact. With imagination and mutual respect between groups, traditional and modern approaches could be combined to develop wildlife management . . . in a way that would be the envy of the world."

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Current Perspectives on the Management of Migratory Birds in Northern Canada and Newfoundland

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Introduction

Canada is seeking to establish conservation regimes for migratory birds that would allow regulation of the northern harvest of waterfowl during the present closed season and the harvest of murres during the fall and winter period in Newfoundland. Implementation of these regimes will require amendments to the Migratory Birds Convention of 1916 (MBC) between Canada and the United States since the Convention prohibits hunting migratory birds from March 11 to August 31 and precludes the hunting of murres.

Management of regulation of the northern waterfowl harvest is of particular relevance to the northern aboriginal communities as the majority of the aboriginal waterfowl harvest occurs during the closed season.

Proposals over the past decade that Canada and the United States amend the MBC have attracted considerable attention. Wildlife managers, conservation groups and aboriginal leaders in Canada agree that the MBC, which has serviced for 75 years as a model for agreements on the conservation of internationally shared species throughout the world, needs to be amended (Thompson et al. 1990). As a consequence, the Canadian Wildlife Service (CWS) is developing an approach through public consultations that will ensure conservation by providing fairer and equitable northern access to waterfowl, and allowing regulation of the murre harvest in Newfoundland.

The purpose of this paper is to summarize legal, policy and biological issues pertaining to waterfowl hunting during the present closed season in northern Canada and to the hunting of murres in Newfoundland.

Waterfowl Management in Northern Canada

Most migratory bird hunting by aboriginal communities occurs in the remote northern regions of the provinces and in the territories where the human population generally resides in small communities. The majority of aboriginal residents utilize wildlife to varying degrees (Freeman 1976, Scott 1987). Finney (1990) has identified a total of 38 major aboriginal harvest areas through Labrador, central and northern Quebec, northern Ontario, central and northern Manitoba, northern Saskatchewan, northern Alberta, and both territories. While aboriginal hunting of ducks, geese and other migratory birds is largely incidental to other traditional harvesting activities, geese form a high percentage of the diet in some communities, notably those along the Ontario and Quebec coasts of James Bay. Most of this harvest occurs during the spring and summer closed season period (Finney 1990) as a consequence of dietary preferences, traditional activities and seasonal availability of birds. Presently, the Migratory Birds Convention Act (MBCA) hunting regulations do not allow for this closed season harvest.

The magnitude of the northern aboriginal waterfowl harvest is now being measured with some precision in several of the northern areas (Usher 1985). Estimates, which require further refinement, indicate an annual harvest of between 250,000 and 750,000 ducks and 350,000 geese (Finney 1990). For comparison, harvests of 350,000 ducks and 350,000 geese represent 13 percent and 32 percent of the Canadian harvest, respectively, and 6 percent and 14 percent of the total North American harvest (K. Dickson, personal communication: 1991). The number of aboriginal waterfowl hunters in all of northern Canada totals about 50,000 individuals (Cooch 1986). Information is lacking on harvest and numbers of aboriginal waterfowl hunters in southern Canada, although this is not thought to be of any significance (Finney 1990).

The aboriginal harvest of some goose populations in Canada can be significant but there are no known instances in Canada, similar to those in southeastern Alaska, where some goose populations are presently limited partly by aboriginal harvesting pressure on breeding stocks. Nevertheless, local reductions in northern Canadian waterfowl populations have occurred, as has been reported for Common Eiders in the vicinity of Cape Dorset, Baffin Island (Finney 1990).

In these northern regions of Canada, there is also a fall hunt by nonnative permit holders. According to data drawn from the National Harvest Survey Program, in 1985–1989, an average of 11,000 permit holders annually harvested about 80,000 ducks and 40,000 geese (Dickson, K. personal communication: 1991).

The 1917 Migratory Birds Convention Act (MBCA) provides for the Canadian regulation and management of waterfowl resources. Regulations determine huntable species, largely ducks and geese, and establish controls over hunting seasons which include a total ban on hunting between 11 March and 31 August, inclusive. Exceptions are provided in the MBCA for aboriginal hunting of scoters for food during the closed season and harvesting at any season the birds and eggs of five other groups (auks, auklets, guillemots, murres and puffins). Waterfowl hunting regulations are established annually in Canada and adjusted to reflect conservation needs for the resource. In the north, as elsewhere in the country, the regulations apply only to the open hunting period and presently do not allow any flexibility to regulate hunting during the closed season.

In conjunction with the MBCA hunting regulations, management of the fall migratory bird harvest in northern Canada is now supported through the direct involvement of aboriginal communities under aboriginal comprehensive claims agreements. These modern agreements, like earlier Indian treaties, derive from government policy—that the claims of aboriginal people be dealt with by negotiation and treaty. Three agreements between the federal government and aboriginal claimants have already been reached in the north: James Bay and Northern Quebec Agreement 1975, Northeastern Quebec Agreement 1978, and the Inuvialuit Final Agreement 1984. Negotiations to settle other aboriginal claims in the Yukon, Northwest Territories, Labrador and Quebec are continuing. The final agreements will establish mechanisms for management of wildlife harvesting, including fall waterfowl hunting, for most of the aboriginal harvest areas identified by Finney (1990). Implementation will include necessary comprehensive harvest studies and the establishment of cooperative wildlife management boards. These steps will complement the continental waterfowl management regime through such programs as the Arctic Goose Joint Venture, and ensure sustainable use of the waterfowl resource for local needs (D. Russell personal communication: 1990).

It is anticipated that the northern comprehensive claims agreements will also provide a mechanism for local community involvement where new regimes are established allowing northern waterfowl hunting during the present closed season. However, to achieve comprehensive regulation and conservation of northern waterfowl, certain provisions of the MBC restricting the open hunting season will first need to be amended (Thompson et al. 1990).

Murre Management in Newfoundland

The coastal waters of Newfoundland and Labrador are the principal wintering areas of thick-billed Murres in the western Atlantic. The over-wintering population of this species totals approximately 5.2 million with smaller numbers of common murres (Elliot 1991).

Hunting of murres and other seabirds has traditionally been a major source of fresh meat in winter, supplementing a largely fish diet. Ninety-five percent of the murre harvest occurs in coastal waters of the island of Newfoundland with the remainder taken along the Labrador coast. The hunt continues to provide food for up to 15,000 individuals and their families (Elliot et al. 1991). The birds are shot from flocks by hunters in open boats, up to 10 kilometers or more from shore, a hunting method that is restricted to times when sea conditions are calm and pack ice is not continuous (Gaston et al. 1983).

The murre harvest has increased significantly with improvements in hunter mobility and efficiency. As a result, the average annual harvest level increased to between 600,000 and 900,000 during the 1980s, based on recent CWS harvest surveys (Elliot et al. 1991). The total annual harvest could exceed one million birds in some years and compares to the total Canadian kill of Mallards, the most heavily harvested duck in the country (Elliot et al. 1991).

Present information from field studies indicates that 95 percent of murres shot in Newfoundland are thick-billed murres that breed in arctic Canada and western Greenland. Their status requires close monitoring because of their low reproductive rate. Studies by CWS have not shown, with one exception, recent declines in Canadian breeding colonies. However, Greenland populations, that are hunted near the colonies and on the Newfoundland wintering grounds, have dropped by at least 40 percent during the last 60 years. The Newfoundland harvest appears to be near the maximum sustainable level, and it is thought that these populations may be unable to sustain additional losses, whether from hunting, drowning in gill-nets or oil mortality (Elliot 1991, Nettleship and Evans 1985).

Difficulties posed by the MBC also arise with respect to managing the harvest of murres in Newfoundland, since murres are designated as non-game birds under the MBC and therefore protected from hunting.

At the time the MBC was signed, murre hunting was already a tradition in Newfoundland, which was then a British colony. When Newfoundland joined Canada in 1949, the hunting of migratory birds became subject to provisions of the MBCA. Proposals to close the murre hunt were strongly opposed in Newfoundland as murres provided an important source of winter food in isolated rural communities. Accordingly, in 1956 the federal government established Section 5(2) of the Migratory Birds Regulations, which authorized murre hunting in Newfoundland. This regulation entitles provincial residents to hunt murres for food from September 1 to March 31 without a permit and without a limit on the number of birds taken. While this regulation prohibits the sale of murres, it does not provide for restriction of the harvest for conservation purposes, such as through the introduction of daily bag limits or reduced seasons. The MBC provisions need to be amended so as to provide the flexibility necessary to regulate and control the murre harvest to ensure that populations are not reduced.

Convention Amendments for Northern Waterfowl and Murres

Efforts have been underway since the mid-1970s to amend the MBC allowing the establishment of management regimes for northern waterfowl and, more recently, for murres, that would provide for conservation and equitable allocation of the harvest.

Acknowledging the difficulties created by the MBC for northern aboriginal waterfowl hunters, the federal government committed in the 1975 James Bay and Northern Quebec Agreement to attempt to amend the Convention. An identical commitment is found in the 1984 Inuvialuit Comprehensive Claims Agreement for the Western arctic region.

Canada and the United States reached agreement in 1979 on an overall approach to amending the MBC that would have allowed a regulated subsistence spring hunting of game birds by Alaskan residents and Indians and Inuit in Canada. Principal objections to this approach seem to have been the lack of prior consultation, the uncertainty with respect to conservation goals and the exclusion of non-native northern residents (Finney 1990). In Canada, progress in developing an implementation plan in response to these objections was delayed as the federal government's ability to retain jurisdiction for migratory birds under an amended MBC was clarified. These legal problems, explained by Finney (1990) and Thompson et al. (1990), related to the status of the MBC as an empire treaty and have since been addressed.

Criteria for amendments to the MBC were subsequently developed and approved at the 1988 meeting of Canadian Wildlife Ministers. Implementation of northern harvests during the closed season must satisfy six criteria: ensure the conservation of migratory birds; allow regional flexibility in application; all residents should potentially benefit if an area is opened for hunting; shared administrative arrangements should be maintained and enhanced; the federal government retains authority with respect to matters under the MBC; and all amendments to the MBC must bind both Canada and the United States.

Provincial and territorial wildlife directors met at the June 1990 Federal-Provincial Wildlife Conference and recommended to CWS that consultation with interested Canadian groups should proceed. Consultations with the aboriginal organizations, wildlife management boards and environmental organizations in the north are now underway. There have also been discussions with national native and environmental organizations. This process is intended to assist in the development of a Canadian position on implementation of Convention amendments and is expected to be completed by spring 1991. Though optimistic, the present timetable is to complete negotiations and reach agreement with the United States by 1992. Subsequent ratification by the Canadian Parliament and U.S. Senate would mean that that new regulations could possibly be in place as early as 1995.

These consultations in Canada have been focused on the desirability of establishing special spring and early fall hunts in northern Canada, where most of the aboriginal harvest occurs and where potentially all residents of the region would be involved. In northern regions, migratory birds arrive late and leave early, restricting the time that aboriginal and non-native hunters have legal access to the resource (Finney 1990, Thompson 1990). Attention has also been given to ensuring that the MBC amendment is broad enough to satisfy the future management of hunting during the closed season in areas of southern Canada where aboriginal or treaty rights to migratory birds may subsequently be confirmed.

It has been generally understood that regulation of the murre harvest, through an amendment to the MBC, would likely occur in parallel with the process of securing amendments to regulate the northern closed season harvest. As a consequence, the CWS conducted extensive consultations with the Newfoundland murre hunters during the 1980s. Murre hunters contacted support harvest restrictions to ensure conservation of hunted populations (Elliot 1991) and increases in penalties for violators who continue to sell birds illegally. Consultations have also been held with key Canadian conservation organizations, all of whom support the establishment of a legal and regulated murre harvest.

Although further discussion is necessary to update Canadian interest groups, the CWS believes that the preferred amendment would allow residents of Newfoundland to take murres for food under regulation during the fall and winter period. This amendment, which would provide an exception to the non-game status of murres, would resolve a significant wildlife management problem created when Newfoundland joined Canada and became subject to the MBC. CWS has already completed the studies necessary to develop appropriate regulations (Elliot 1991). Section 5(2) of the MBCA would be replaced once the Convention is amended and a flexible management system with effective harvest controls would then be established. Elliot et al. (1991) and Elliot (1991) provide detailed analyses of the characteristics of the hunt and the regulatory mechanism that will be required to safeguard the population and maintain a sustainable rate of harvest.

Discussion

Several important questions are now being addressed through consultations in Canada concerning the northern waterfowl harvest. Their resolution will guide implementation in Canada of MBC amendments. Identification of zones is essential, for example, where spring and early fall hunting would be established in northern Canada. The settlement regions under the James Bay and Northern Quebec Agreement and the Inuvialuit Agreement would likely be involved in these hunts, following commitments in these agreements to amend the MBC. Other areas in the territories and northern portions of the provinces would also be involved but as yet are not clearly identified. Assigning greater precision to the identification of areas where equitable northern access is precluded will assist in guiding the identification of hunting zones and clarifying the likely impact of a regulated harvest on the resource. Accordingly, CWS analysis is currently underway to describe the seasonal movement and abundance levels of birds, particularly geese, and the availability of birds during the spring and fall.

Also under discussion is the approach of allowing non-native residents to participate in regulated harvests during the present closed season. In remote aboriginal communities this approach would allow non-native northerners, who rely on subsistence hunting, a legal opportunity to participate in the harvest and to share responsibilities for conservation of the resource. On the other hand, the expected build-up of new communities, for example, in northern Quebec where hydro development is proceeding, suggests that non-native participation in the harvest will need to be carefully controlled so as to avoid additional mortality on breeding populations. Further consideration of non-native participation will require greater precision, in terms of the number of individuals involved, the locations of hunting zones, residency requirements and projected impacts on the resource.

Treaty and aboriginal rights in Canada that may exist to harvest migratory birds during the closed season are also to be considered in amending the MBC. There is a great deal of uncertainty respecting the establishment of hunting zones in southern Canada required to regulate the exercise of aboriginal or treaty rights to migratory birds that may exist during the present closed season. Presently, broad treaty rights exist to harvest wildlife for food, subject to conservation, and the case law is inconclusive concerning the extent to which the MBCA has extinguished these rights, now protected under the Constitution Act of 1982 (Finney 1990).

As a consequence, legal challenges to migratory bird legislation, particularly the closed season provisions, are likely to continue. Recent lower court decisions in Manitoba (R.v. Flett 1989) and Alberta (R.v. Arcand 1989) determined that section 35 of the Constitution Act, 1982 protects treaty rights including the harvest of waterfowl during the present closed season, and that the MBCA went beyond the kind of regulation provided for in the treaties at issue. These decisions preceded the 1990 Supreme Court of Canada decision (R.v. Sparrow) that allowed federal regulation of aboriginal rights, in this case fishing rights, for purposes of conservation. While it is difficult to predict the outcome of future challenges to the MBCA, it is clear that MBC amendments must respect whatever protection the Constitution gives to aboriginal and treaty rights to hunt migratory birds in Canada (Thompson 1990).

Conservation mechanisms to manage the northern closed-season harvest of waterfowl will also need to be described and, where necessary, established. Comanagement regimes for wildlife in the northern comprehensive claims areas provide the necessary conservation and management tools to ensure local community participation in management of the waterfowl resource for harvesting that now occurs during the fall. Where a managed and legal hunt for ducks and geese during the closed season is established, conservation could be achieved through these same mechanisms. Where such mechanisms do not exist, such as certain provincial areas where government and aboriginal wildlife management boards are absent, the opportunities for comanagement of waterfowl need to be examined and developed.

In the past, Canadian interest groups have supported regulations in Newfoundland that would reduce the murre harvest as a result of compelling scientific findings. This support and hunter willingness to cooperate for conservation and sustained use of the murre population now needs to be confirmed and a formal process initiated to amend the Convention. A major cost of delay in amending the MBC may be the eroding of support for harvest restrictions amongst the murre hunters.

Conclusions

A comparison of the northern waterfowl and murre harvests reveals similar characteristics: traditional harvest for food in remote areas; the need to amend the Convention for conservation; and to involve local communities in management of the resources. However, the central issues of each differ in two ways. First, the murre harvest does not involve matters related to aboriginal rights, since Indians and Inuit are able to legally harvest murres year-round for food. Second, the Newfoundland murre harvest affects bird populations that rarely reach the United States and are not harvested in that country. It is a Canadian problem that cannot be solved through purely domestic action. In the case of northern access amendment, the implications of aboriginal rights to waterfowl are national in scope and the harvested migratory bird populations are shared and managed with the cooperation of the United States and Mexico.

Amendments to the MBC will require agreement between Canada and the United States. Those changes are necessary in Canada for conservation and good management of northern-harvested waterfowl, where responsive regulation is now limited to the open season, and for conservation of the murre population wintering in coastal waters of Newfoundland.

The establishment of legal regimes in northern regions allowing spring and early fall hunting will contribute to conservation of waterfowl populations through regulations, controls and local involvement. It is anticipated that conservation can be assured through the development of wildlife management regimes for co-management of the waterfowl resource. Similar arrangements and continued federal regulation for conservation of migratory birds will need to be established in southern Canada for those aboriginal communities, where rights to hunt during the closed season may be found to exist. Consultations in Canada on the development of a preferred approach to amending the Convention are now addressing key aspects of implementation including geographic scope, eligibility, aboriginal and treaty rights, and conservation regimes. These consultations are at a preliminary stage.

In Newfoundland, where support can now be found for regulations controlling the murre harvest, the Convention will also need to be amended to allow an exception to the protected status of murres for residents to harvest the birds under regulation. The need to manage the harvest is significant since studies indicate that the current harvest levels may be close to the sustainable level of the wintering population.

The Migratory Birds Convention remains an effective conservation and management tool to preserve migratory birds and sustain their use throughout North America. The unfinished business of northern access and murre hunting are two very significant wildlife management issues. The resolution of these issues is long overdue and can only be achieved with a concerted effort on the part of wildlife managers and resource users alike.

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Special Session 7. *Challenges from Animal Rightists*

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Challenges from Animal Rightists: Can We Identify Common Goals?

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Introduction

Controversies surrounding animal rights advocates are regularly portrayed by the televised and printed media. We hear of threats to animal research laboratories and to laboratory personnel, protests of hunts and harassment of hunters, protests of the use of foot-hold traps and the decline in the fur industry. "Conflicts between animal rights groups and management agencies are increasing in frequency and cost" (Soule 1990:235).

We organized this session to help wildlife and natural resources professionals become familiar with and aware of the issues and goals of animal rights advocates, and to identify means of minimizing controversy between animal rights advocates and sound resource management. To begin this session, we will provide background about animal rights advocates, define differences between a humane ethic and the land ethic of Aldo Leopold, and attempt to identify potential common ground. The differences between natural resource managers and animal rights advocates may be irreconcilable; but we must find similarities and search for common goals. The popular media, where controversy and differences are part of what defines "the news," will not resolve our differences.

Distinction Between Animal Rights and Animal Welfare

Robert Schmidt (1990) distinguished between animal welfare and animal rights in a recent *Wildlife Society Bulletin* article. People who support animal welfare believe that all human activities involving animals should be conducted in ways that minimize the animal's physical and psychological discomfort. Numerous federal laws promote animal welfare (Garbe and Wywialowski 1991). We believe that wildlife and natural resource professionals support animal welfare.

Animal rightists believe that in addition to humane treatment, all animals have an inherent right to life without suffering. Extreme animal rightists believe that the use of all animals by humans should be stopped including use of animals as pets, in zoos and circuses, for research, and for meat, leather or furs. Animal rights proponents frequently take visible actions in pursuit of their goals, and their activities may differ from the principles of animal rights espoused by philosophers such as Peter Singer and Tom Regan. The ideology of the animal rights movement and the characteristics of some animal rights advocates will be further discussed in a paper by Richards and Krannich (1991). Some of the strategies that animal rightists have used to address their concerns are the subject of papers on bowhunting (Samuel et al. 1991), trapping (Proulx and Barrett 1991) and harp seals (Tilt and Spotila 1991).

Philosophical Argument for Animal Rights

Philosophers have been the main articulators of principles for animal rights. Singer extended the principles of animal welfare, emphasizing reduction of the suffering of individual beings. Singer believes that freedom from suffering is a basic moral right held by all animals. In *Animal Liberation*, (1975:3) he argued that we should strive for equality of consideration among the species; but that "equal consideration for different beings may lead to different treatment and different rights." With regard to the relative suffering of hunted species and domestic livestock, Singer (1975:243) offered the following comment: ". . . there are some cases where I do not think distinctions can validly be drawn at all. Why, for instance, is the hunter who shoots wild ducks for his supper subject to more criticism than the person who buys a chicken at the supermarket? Over-all, it is probably the intensively reared bird who has suffered more."

Regan, who has written numerous books in the animal rights area, disagrees with Singer on various points and holds as his basic principle that each animal has an inherent right to life (Regan 1983). According to Regan (1982), Singer's arguments for animal rights are flawed because they are based on utilitarian principles of maximizing the balance of good over evil with consideration to all species of animals. Regan's arguments are, in his words, "more cerebral" than applied.

Contrasts Between Animal Rightists' and Environmentalists' Philosophies

Regan did not address the means to resolve disputes between individuals, nor did he address the collective rights of populations or communities. Callicott (1980) contrasted the ethical foundations of the "animal liberation" movement and Aldo

Leopold's land ethic. The humane ethic emphasizes minimizing pain for each individual, while the land ethic considers the good of the community as a whole.

According to Callicott (1980:318), the fundamental principle of humane moralism is that "good is equivalent to pleasure and, more pertinently, evil is equivalent to pain." The unit of consideration and importance is the individual. In the land ethic, "the land is one organism" (Leopold [1949]1989:190). Good and evil are to be judged relative to how they affect the entire ecosystem. "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community. It is wrong when it tends otherwise" (Leopold [1949]1989:262).

Commonalities

What do we, as natural resource managers, have in common with animal rightists? If we expand their concerns to include not just individuals but the community of life, our commonalities might exceed our differences. Similar to Regan's view that individuals have inherent rights, Karr (1990:248) stated that: "a move away from the ethical, theological, political, economic and management perspectives that place human life and products above the 'less useful' nonhuman life would aid attainment of biodiversity goals."

Similarly, Western et al. (1989:318) stated that the hope for the future of conservation biology lies in a nonanthropocentric view in which humans grant a value to nature that resides within nature itself, not as defined by its utility to man. In our opinion, nothing inherent in these views precludes sound natural resource management activities.

Win-Win Approach

According to Hutchins and Wemmer (1986/1987:131): "Enlightened solutions to the problems of the humane treatment of animals and environmental concern can best be achieved through collaboration. Participation in cooperative problem solving through regular meetings, workshops and symposia should enhance awareness of concerns vital to each group's interests."

Tilt and Spotila (1991), Gilbert (1991), and Race et al. (1991) suggested some solutions to the animal rights versus wildlife management problem. The results of such an approach for urban deer management was presented by McAninch and Parker (1991). Minimizing "conflicts will require both public education and courageous leadership . . . to inform the public about the complex biological and ethical issues involved in these conflicts" (Soule 1990:235). Information and education efforts of all natural resources agencies will be challenged to meet these needs.

Animal rights advocate Henry Spira (1985:207) described some of the campaigns of animal rightists and their strategies to achieve their goals: "Our aim is not to conquer our opponents. . . . We are interested in getting things done, not in pushing people around. . . . To fight successfully we need priorities, plans, effective organization, unity, imagination, tenacity and commitment." The same could and indeed should be said of the wildlife and natural resource profession in meeting the challenges of the animal rights movement. We hope that this session enhances natural resource managers' options to answer the challenge.

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The Ideology of the Animal Rights Movement and Activists' Attitudes Toward Wildlife

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Introduction

Since the mid-1970s, animal rights activists have created a broad-based social movement which has posed formidable challenges to wildlife management. In protesting what they perceive to be the abuse of animals, animal rights activists have actively opposed traditional wildlife consumption practices such as hunting and trapping (Herscovici 1984) and challenged the precepts upon which the wildlife management profession is based (Decker and Brown 1987).

It is generally thought that the animal rights movement is not a new phenomenon but is rooted in the anti-vivisectionist movement of the Victorian era which objected to the role of animals in scientific experimentation. However, much of the opposition to the treatment of animals which the modern animal rights movement has expressed has been directed beyond physiological experimentation toward a much wider range of human practices involving animals. In opposing all human consumption of animal products, for example, contemporary animal rightists are thought to differ fundamentally from their Victorian anti-vivisectionist precursors by claiming that animals not only deserve humane treatment but are entitled to the same rights as humans (Holden 1987). The intellectual basis of this view countering human "speciesism," or the divine rights of *Homo sapiens* as sentient beings, has its modern roots in a school of philosophers active at Oxford University during the 1960s and 1970s. From these esoteric philosophic roots, speciesism was first popularly disseminated by one of the members of the Oxford group, Peter Singer, in his book *Animal Liberation* in 1977 (Sperling 1988). Thus, in its ideological values and its ethical assumptions, the contemporary animal rights movement is thought to differ radically from its Victorian anti-vivisectionist predecessor (Holden 1987).

Establishing the actual characteristics of the ideological nature of the animal rights movement has, however, been constrained by a lack of sociological research. Despite widespread recognition of the growth and breadth of the modern animal rights movement, relatively little is known about the characteristics and attitudes of the people who join. Current research by Jasper and colleagues indicates that activists in various parts of the movement are fairly diverse with strong left-liberal leanings (Jasper and Poulsen 1989). But just who animal rights advocates are and what attitudes have led them to become committed to the movement are questions yet to be completely addressed. Elucidating the ideological nature of the contemporary animal rights movement and the attitudes of activists' towards animals was the focus of the research reported here.

Methods

In 1990, a national mail survey was conducted of animal rights activists. The survey sample consisted of subscribers to *The Animals' Agenda*, a 10-issue annual animal rights magazine which has been published since 1981. With a current circulation of 25,000, *The Animals' Agenda* is unaffiliated with any single animal rights social movement organization and, as such, is considered the leading independent animal rights publication (S. Kellert personal communication: 1987). Coöperation from *The Animals' Agenda* allowed access to its subscriber list at no charge. Personnel at *The Animals' Agenda* subscription office initially drew a systematic random sample of 1,400 individual subscribers in the United States from their total list of subscribers by computer (P. Hoyt personal communication: 1989). From this sample, subsamples of 75 pretest respondents and 1,020 main wave respondents were randomly selected for survey administration. A mail questionnaire was designed, pretested and administered to the main survey sample of 1,020 subscribers. A total of 853 completed questionnaires were returned for a total response rate of 84 percent.

The survey designed for this study allowed for comparing the sample of *Animals' Agenda* subscribers with the general U.S. population through replication of a number of questions drawn from other national surveys for which responses in the national population were known. These included National Opinion Research Center (NORC) and Gallup Poll questions on attitudes towards the environment and Kellert's U.S. Fish and Wildlife Service survey questions on wildlife, as well as nationally comparable sociodemographic indicators and measures of social attitudes drawn from Harris, Gallup, NORC and other polls (*see* Gilbert 1988, National Opinion Research Center 1989). In all cases, unless otherwise noted, these comparisons were drawn from the most currently available (1980) census data (U.S. Bureau of the Census 1983a, 1983b).

Results

Sociodemographic Characteristics

Some observers of the animal rights movement claim that the ideological shift from humane concern to speciesism has occurred because animal rightists tend to be young urbanites whose only experiences with animals have been through anthropomorphized television programs and family pets (Holden 1987). Similar sociodemographic characteristics have been identified for environmentalists, who have generally been found to be young, predominately white and well-educated urban professionals (Buttel and Flinn 1974, Van Liere and Dunlap 1980). In addition, women seem to be much more involved in the animal rights movement than are men, and more animal rights activists seem to be active on the east and west coasts than in other parts of the country (Sperling 1988). In general, the stereotype of an animal rights activist is "a 33-year-old white woman, probably a nurse, school teacher, or government worker, with pets, environmental sympathies, a family income of $31,000 a year, a college degree, and an urban residence who is 'what the sociologists call a classic disaffected leftist—highly educated but underemployed' " (Animal Rights Network, Inc. 1990:29).

Results from the survey confirm some, but not all, of the stereotype and further indicate that the average survey respondent differs considerably from the average American citizen. As shown in Table 1, both the West Coast and East Coast states were overrepresented in the sample by 5.1 percent and 4.2 percent respectively. In contrast, the southern states were considerably underrepresented in the sample by 8.5 percent and the central states only slightly so by 0.7 percent. The mountain states were proportionally represented in the sample.

Respondents were far more likely to be women than men (Table 1). Almost four of five respondents were female, whereas the male-to-female ratio is just slightly less than 1:1 in the national population. Certain categories of age were also markedly different for the survey respondents in comparison to the general population. In general, young and old respondents were underrepresented in the sample by 26.8 percent and 6.1 percent, respectively. In contrast, middle-aged individuals were overrepresented in the sample by 32.5 percent.

As shown in Table 2, respondents appeared to be no more urban than the general population since the survey and census distributions for place of residence were almost the same. However, respondents were much more likely to be very well educated than individuals in the general population. Almost half of the respondents had completed some college or a baccalaureate degree and a third had completed an advanced, postgraduate college degree. As a whole, those who had attended college or graduated from college were overrepresented in the sample by 50.2 percent.

Differences in the amount of gross household income between respondents and the national population paralleled these differences in education (Table 2). Respondents reported being very well-to-do, with almost one in four receiving incomes of

Table 1. Summary sociodemographic characteristics for region, sex and age.[a]

Variable	Survey percentage	1980 census percentage
Region (n = 848)		
Pacific	19.1	14.0
Mountain	5.0	5.0
Central	25.3	26.0
South	24.5	33.0
East	26.2	22.0
Total	100.1	100.0
Sex (n = 844)		
Male	21.7	49.0
Female	78.3	51.0
Total	100.0	100.0
Age (n = 849)		
Under 29	23.2	50.0
30 to 49	56.6	24.1
50 or over	20.0	26.1
Total	99.8	100.2

[a]Totals may not add to 100 percent due to rounding error.

Table 2. Summary sociodemographic characteristics for place of residence, education and income.[a]

Variable	Survey percentage	1980 census percentage
Residence (n = 844)		
Urban	73.4	73.6
Rural	26.6	26.2
Total	100.0	99.8
Education (n = 847)		
Grade 12 or less	17.9	68.2
BA, some college	48.8	24.3
MA or Ph.D	33.3	7.6
Total	100.0	100.1
Income (n = 817)		
$19,999 or less	18.4	58.5
$20,000–$49,999	42.5	36.8
$50,000 or more	38.9	4.6
Total	99.8	99.9

[a]Totals may not add to 100 percent due to rounding error.

$50,000 or above. Compared with the national population, respondents with incomes of $50,000 or above were overrepresented in the sample by 34.3 percent, while those with incomes of $19,999 or less were underrepresented in the sample by 40.1 percent.

These economic differences were reflected in the reported racial or ethnic background of respondents as shown in Table 3. Respondents were almost exclusively white and, in relation to the general population, were overrepresented in the sample by 13.9 percent.

Other socioeconomic differences between respondents and the national population are reflected in the distribution of occupations (Table 3). Slightly less than half of

Table 3. Summary sociodemographic characteristics for race, occupation and employment status.[a]

Variable	Survey percentage	1980 census percentage
Race (n = 841)		
White	96.9	83.0
Non-white	3.1	17.0
Total	100.0	100.0
Occupation (n = 821)		
Executive	46.3	22.7
Technical, sales	28.1	30.3
All other	25.6	47.0
Total	100.0	100.0
Employment (n = 836)		
Full-time	60.0	62.0
Other	40.0	38.0
Total	100.0	100.0

[a]Totals may not add to 100 percent due to rounding error.

the respondents reported that they held executive or managerial positions, an over-representation in the sample of 23.6 percent. However, respondents were no more likely to be without full-time work than the general population.

Finally, as shown in Table 4, while comparable census data are not available, 7 of 10 respondents reported having no living children. Although 3 of 10 respondents did have children, fewer than 2 of 10 said their children were living with them at the time of the survey. In comparison, almost 9 of 10 respondents said that they owned at least one pet. The mean number of pets reported was 4.7.

Ideological Orientations

In her study of California Bay Area animal rights activists, Sperling (1988) found that previous involvement in the women's, gay rights and/or environmental movements often was associated with animal rights involvement. This is consistent with Jasper and Poulsens' (1989) finding that animal rights activists are generally left-leaning liberals.

As shown in Table 5, results from the survey confirm these findings. When asked to what degree they were involved in 10 well-known, contemporary social movements, respondents were far more likely to be now or previously active in environmentalism than any of the other social movements. More than 7 of 10 respondents indicated that they were presently or previously active in the environmental movement. In contrast, just 2–3 of 10 respondents indicated that current or previous activity in the anti-war, civil rights and anti-nuclear movements. However, while they were less involved in these movements than in environmentalism, over half of the respondents were sympathetic to these four movements. Similarly, almost 1–2 of 10 respondents said they were now or previously active in the student, free speech and anti-apartheid movements, and 5–7 of 10 respondents said that they were sympathetic to these three movements.

Table 4. Summary sociodemographic characteristics for number of living children, children at home and pet ownership.

Variable	Survey percentage
Living children (n = 846)	
No	70.6
Yes	29.4
Total	100.0
Children at home (n = 853)	
0	83.8
1 or more	16.2
Pet ownership (n = 848)	
No	11.3
Yes	88.7
Total	100.0
Number of pets (n = 853)	
Mean	4.7
Median	3.0
Standard deviation	7.72

Table 5. Respondents' ideological orientations towards other social movements.[a]

Movement	Percentage				
	Active	Sympathy	Neutral	Opposed	Total
Environmental (n = 847)	72.2	26.2	1.2	0.3	99.9
Anti-war (n = 843)	29.5	54.3	10.4	5.6	99.8
Women's (n = 847)	26.0	57.3	11.5	5.4	100.2
Civil rights (n = 840)	25.4	63.4	9.2	2.0	100.0
Anti-nuclear (n = 840)	23.8	58.6	10.2	7.4	100.0
Student (n = 842)	17.0	53.9	24.8	4.3	100.0
Anti-apartheid (n = 832)	13.1	73.2	10.3	3.4	100.0
Gay rights (n = 847)	8.6	45.6	24.9	16.9	100.0
Pro-life (n = 840)	8.4	17.6	12.5	61.4	99.9
Pro-school prayer (n = 844)	3.1	19.2	23.9	53.8	100.0

[a]Totals may not add to 100 percent due to rounding error.

In contrast, respondents were somewhat more ambivalent about gay liberation with fewer than 1 of 10 saying that they were now or previously active in gay rights and less than half saying they were sympathetic to the gay rights movement. Finally, respondents were generally inactive in, and unsympathetic to, two conservative social movements, the pro-life (anti-abortion) and pro-school prayer movements. In all, more than 5 of 10 respondents said that they were opposed to these two movements while fewer than 2 of 10 said that they were opposed to any of the other eight social movements, including gay liberation.

Attitudes Toward the Environment

The high rate at which respondents reported being involved in the environmental movement is reflected in their attitudes towards environmental issues, as shown in Table 6. In five questions replicated from a 1984 Gallup Poll (Gilbert 1988), respondents reported much more concern about environmental issues than did the national population. Of the five issues, the national population was most concerned

Table 6. Respondents' (n = 852) concern about national environmental issues.

Issue	Degree of concern (percentage)					
	Great deal		Fair amount		Not much or not at all	
	Survey	Gallup	Survey	Gallup	Survey	Gallup
River/lake pollution	94.9	52.0	4.9	32.0	0.1	16.0
Sea life damage by oil spills	97.3	54.0	2.3	27.0	0.3	19.0
Air pollution	91.8	46.0	7.9	32.0	0.3	22.0
Disposal of industrial waste	93.1	64.0	6.6	22.0	0.3	14.0
Disposal of nuclear waste	93.6	69.0	5.4	17.0	0.7	14.0

about the disposal of nuclear waste, while survey respondents were most concerned about damage to sea life by oil spills.

Attitudes About Wildlife

As shown in Table 7, respondents' views towards the environment were reflected in their concerns about wildlife. In questions replicated from a U.S. Fish and Wildlife Survey conducted by Kellert and his colleagues between 1977 and 1980, respondents reported far more concern for wildlife habitat protection than did the national population. Like the general population, respondents most strongly approved of cutting trees for lumber and paper in ways which would help wildlife even if higher timber prices resulted. Respondents and the national population also disapproved most of building on marshes which ducks and other nonendangered wildlife used if the marshes were needed for housing developments. However, support for wildlife was much higher for respondents than the general population—19.7 percent more respondents agreed that logging should protect wildlife and 37.3 percent more respondents disagreed that marshes should be developed for housing.

Attitudes Toward Animals

Finally, a series of 15 questions was developed for the survey to ascertain the degree to which respondents thought human treatment of various animals was wrong. All of these items were measured on a one to seven scale, which ranged from extremely wrong (coded one) to not at all wrong (coded seven). The scale had a midpoint of four, which would be assumed to indicate neither extremely nor not at all wrong.

As shown in Table 8, descriptive statistics for these 15 items indicate that respondents viewed most human uses of animals as wrong. Only 4 of the 15 items

Table 7. Respondents' views on wildlife habitat protection.[a]

	Percentage agree		Percentage disagree	
Issue	Survey	Kellert	Survey	Kellert
Logging should help wildlife even if timber prices rise (n = 848)	95.7	76.0	2.6	20.0
Cattle and sheep grazing on public lands should be limited if plants needed by wildlife are damaged (n = 839)	83.8	60.0	7.1	34.0
Marshes that ducks and wildlife use should be developed if housing is needed (n = 845)	2.6	39.0	94.3	57.0
Develop natural resources even if wilderness loss reduces wildlife (n = 845)	3.1	44.0	94.1	51.0

[a]Totals do not add to 100 percent because *No opinion* has been omitted.

Table 8. Respondents' attitudes towards animals.[a]

Survey topic	Mean	Median	sd
Leghold traps for wild animals (n = 849)	1.06	1.00	0.46
Animal use in cosmetic experiments (n = 848)	1.13	1.00	0.64
Kill an animal for a fur coat (n = 849)	1.17	1.00	0.82
Sell pound dogs medical experiments (n = 848)	1.29	1.00	1.02
Hunt wild animals with guns (n = 840)	1.49	1.00	1.05
Animal disease medical experiments (n = 845)	1.62	1.00	1.25
Raise cattle for food in feedlot (n = 842)	1.75	1.00	1.31
Use horses for racing (n = 837)	2.68	2.00	1.62
Eat meat (n = 840)	2.74	2.00	1.81
Keep animals in zoos (n = 841)	3.02	3.00	1.67
Raise cattle for food on open range (n = 839)	3.31	3.00	2.06
Kill rats in residential area (n = 823)	4.24	4.00	1.90
Kill cockroaches residential area (n = 836)	5.34	6.00	1.85
Keep a dog or cat as a pet (n = 844)	6.49	7.00	1.11
Neuter a pet (n =.844)	6.62	7.00	0.93

[a]A seven-point scale of one (extremely wrong) to seven (not at all wrong).

had means above 4.00, which would indicate that respondents tended to view these 4 items as somewhat acceptable treatments of animals. Two of the items involved the care of pets. The other two items involved pest control. Respondents greatly approved of keeping a dog or a cat as a pet and indicated even greater, albeit slight, approval to neutering a pet. Killing cockroaches in a residential area was the third most acceptable treatment of animals, followed by more ambivalent approval of killing rats in a residential area.

In contrast, the items which respondents considered most extremely wrong generally involved trapping, hunting and animal experimentation. Using leghold traps to capture wild animals was considered the most extremely wrong treatment of animals of any of the 15 items. This was followed by using an animal for a cosmetic experiment, killing an animal for a fur coat, selling unclaimed pound dogs for use in medical experiments and hunting wild animals with guns.

Conclusion

In general, the survey findings confirm many of the characteristics associated with the stereotypic animal rights activist. Most respondents were highly educated, relatively well-to-do female professionals. Their involvement in, or sympathy with, other social movements indicates liberal orientations to other political and social issues, especially environmentalism. Their commitment to environmental activism is also reflected in their concern for environmental degradation and support for wildlife habitat improvement.

Although the survey results cannot confirm the contention that activists' attitudes toward animals typify the ideology of speciesism, the findings do indicate that animal rightists view many commonly accepted human practices involving animals as very wrong. In particular, activists consider trapping and hunting as particularly objectionable and generally view trapping and hunting issues as wrong as animal use in scientific experimentation.

The implications of these findings for the wildlife management profession are several. One is that the concerns which animal rights activists have for improving the environment and protecting wildlife habitat surpass those of the general population. In principle, animal rights activists should prove supportive of many of the long-term general objectives of wildlife professionals. The second implication, however, is that animal rights activists have strenuous, ethical objections to the traditionally acceptable harvesting of wildlife through hunting and trapping. These particular objections may well override any general concern which they otherwise have towards wildlife habitat. The challenges before wildlife managers, therefore, will be not only to recognize that wildlife attitudes between activists and nonactivists differ but to also reconcile the conflicting demands which animal rights activists themselves present.

Acknowledgments

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The Role of the Federal Government in Humane Treatment of Captive Wildlife

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Introduction

The welfare of animals concerns both the public and those individuals and entities whose activities affect animals. In response to the growing concern for animal welfare, Congress enacted legislation to regulate the use of animals in various activities. A brief historical account of the legislation is followed by a more detailed explanation of federal regulation. Implications for wildlife researchers, in light of the trends in animal welfare development, is explored as is the likely future federal role in regulating this activity.

Legislative Authority

The earliest attempt by the Congress of the United States to deal with the issue of animal welfare occurred in 1949 when it amended the Lacey Act of 1900.[1] The amendment prohibited the importation of animals under inhumane or unhealthful conditions. The original authority to promulgate regulations subsequent to this legislation rested with the Department of the Treasury. Regulations were not developed by this department and thus, in 1981, Congress authorized the Department of the Interior to write the regulations. These standards were eventually finalized on November 10, 1987. However, recently the regulations were reproposed and the process of finalization initiated once again.

The Marine Mammal Protection Act was passed in 1972.[2] Its primary focus is to protect marine species in the wild, however, provision is made for obtaining animals for scientific purposes or public display. These animals are to be "taken" in a humane manner. Consequently, implementation of the Marine Mammal Protection Act encompasses aspects of animal welfare.

The first federal legislation directed specifically toward animal welfare was passed by Congress in 1966.[3] Its major purpose was to prevent the sale of stolen pets to research facilities. The only entities regulated were research institutions and dealers of dogs, cats, non-human primates, rabbits, hamsters and guinea pigs. Congress specifically prohibited the Secretary of Agriculture from promulgating regulations that would interfere with conducting research. This statute was significantly amended in 1970.[4] The amendments increased the scope of the legislation to include all warm-

[1]Lacey Act of 1900, Ch 553, 31 Stat. 187, 16 USC 701, 3371–3378, 18 USC 42 (1976 and Supp. V 1981).
[2]Marine Mammal Protection Act of 1972, 16 USC 1361–1407 1976 and Supp. V 1981).
[3]The Laboratory Animal Welfare Act of 1966, Public Law (PL) 89–544.
[4]The Animal Welfare Act of 1970 (AWA), PL 91–579.

blooded species. However, the Secretary was provided the discretion to limit the application of the law. As a consequence, the Secretary excluded from coverage all marine mammals, farm animals, birds, and laboratory mice and rats. Entities such as zoos, circuses, and operators of auction sales where dogs and cats were sold became subject to the provisions of the Act.

The AWA was, again, amended in 1976 to expand the activities included within the scope of the law.[5] Those individuals involved in the transportation of regulated species, including carriers and intermediate handlers, as well as animal fighting ventures now came under the jurisdiction of the law. In 1979, the Secretary of Agriculture authorized the promulgation of standards for the care and maintenance of captive marine mammals, without passage of any new legislation.

The most recent amendments to the AWA were passed in 1985.[6] Research facilities were impacted most significantly. These entities must now ensure that animal pain and distress are minimized during experimental procedures and that investigators consider alternatives to pain-causing procedures. In addition, facilities are required to create Institutional Animal Committees to oversee the research activities within the facility. The Secretary of Agriculture was compelled by these amendments to promulgate standards for the exercise of dogs and to provide for the psychological well-being of non-human primates. Finally, these amendments require the National Agricultural Library to develop a center whose purpose is to disseminate information concerning the AWA and the animal welfare movement.[7, 8]

Federal Implementation of Animal Welfare Legislation

Several federal departments—Agriculture, Commerce, Health and Human Services, and Interior—have agencies that administer regulations touching on the issue of animal welfare.

Department of Health and Human Services—National Institutes of Health (NIH)

Under the Public Health Services Act of 1944, as amended by the Health Research Extension Act of 1985 (PL 99–158), NIH is authorized to require that institutions it funds provide adequate assurance of compliance with the AWA and the Public Health Service Policy on Humane Care and Use of Laboratory Animals. NIH first published its Guide for the Care and Use of Laboratory Animals in 1963. The Guide has been revised several times and continues to provide the basic guidelines for compliance with NIH requirements. These requirements must be fulfilled to receive NIH funding to conduct research. Institutional assurances are to be filed with the Office for Protection from Research Risks (OPRR)[9] located on the NIH campus.

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[5]The Animal Welfare Act Amendments of 1976, PL 94–279.

[6]The Animal Welfare Act Amendments of 1985, PL 99–198.

[7]For more detailed information concerning the history of the animal welfare movement and consequent legislation contact the Animal Welfare Information Center, Room 304, National Agricultural Library, 10301 Baltimore Boulevard, Beltsville, Maryland 20705, phone: (301) 344–3704.

[8]For additional information and detail *see* Silberman (1988). Animal welfare, animal rights: The past, the present, and the 21st century. J. Zoo Anim. Medicine 19(4):161–167.

[9]Office for Protection from Research Risks (OPRR), Office of the Director, National Institutes of Health, 9000 Rockville Pike, Building 31, Room 4B09, Bethesda, Maryland 20892.

Department of the Interior—Fish and Wildlife Service (FWS)

FWS is mandated to protect the interests of endangered species.[10] Very recently, FWS indicated its commitment to the AWA by initiating the development of a Service-wide policy that would assure compliance with the Act by both researchers within the agency and researchers involved in cost-sharing programs in the states.

Policy development in the federal system is tedious and time consuming. It is expected that the development of this FWS policy will proceed very slowly.

Department of Commerce—National Marine Fisheries Service (NMFS)

NMFS, under authority of the Marine Mammal Protection Act, is responsible for protecting marine mammals in the wild and in captivity. NMFS grants permits authorizing both the "take" of marine mammals from the wild and the maintenance of these species in captivity. Before issuing a permit to an institution to maintain marine mammals in captivity, NMFS seeks the assessment of the Animal and Plant Health Inspection Service (APHIS) as to the institution's compliance with the AWA. Without the assurance of APHIS, NMFS will not issue a permit.

Department of Agriculture—Animal and Plant Health Inspection Service

The federal agency with primary responsibility for implementing legislation pertaining to animal welfare is APHIS, U.S. Department of Agriculture. This agency has promulgated regulations that outline what constitutes compliance with the AWA by individuals and institutions.[11]

Persons involved in an array of different regulated activities are required to either become licensed or to register with APHIS. The type of activity determines whether the person needs to be licensed or registered. Broadly speaking, persons conducting research utilizing mammals (exclusive of mice and rats) and those acting as "carriers" and "intermediate handlers" must register with APHIS. Persons must be licensed as "dealers" if they raise and sell mammals for covered activities. Persons exhibiting mammals either in performance or in a traditional zoo must be licensed as "exhibitors." There are, however, exceptions to the requirement for licensure. If an individual is uncertain as to the necessity of becoming either licensed or registered it is suggested that the individual contact the Regulatory Enforcement and Animal Care (REAC) Sector Supervisor for the sector in which he or she intends to conduct the activity for clarification.[12]

Implications for Wildlife and Natural Resources Researchers

The term "animal," as used in the regulations, includes any warm-blooded animal that is being used or is intended for use in research, teaching, testing, experimentation, exhibition or as a pet. Both wild and exotic animals are covered by the regulations. Wildlife research constitutes a "gray" area in terms of regulatory mandate. Activities may or may not fall within the definition of "research." For example, activities

[10]The Endangered Species Act of 1973, 16 USC 1531–43 (1976 and Supp V 1981).

[11]*See* Title 9 of the Code of Federal Regulations, Parts 1, 2 and 3 (1990).

[12]*See* Figure 1—Animal Care Sector Offices.

focusing on the development of techniques for herd management may be exempt. Alternatively, activities that include invasive procedures such as internal placement of tracking devices may be considered "research."

An absolute rule concerning whether or not a particular wildlife activity is considered research is not possible at this time. Circumstances will be reviewed on a case-by-case basis. Again, it is recommended that persons conducting research activities with wildlife species contact the REAC Sector Supervisor for the sector in which the activity is being conducted (*see* Figure 1). It is further recommended that state fish and wildlife agencies create animal care and use committees that have the authority to review research protocols and that can assist in determining the applicability of the AWA.

The Code of Federal Regulations (CFR), part 3, sub-part F provides the standards that must be maintained both at stationary facilities and during transport if an activity is determined to be within the scope of regulatory authority. The standards are divided into three sections; the first dealing with facilities and operations management, the second concerned with animal health and husbandry, and the third which outlines transportation standards.

The first section describes generally the structural strength required of the physical facilities, as well as the necessity for provision of adequate power and potable water. Additionally, issues such as temperature, ventilation, lighting and drainage are considered for both indoor and outdoor facilities. In terms of animal health and husbandry, the regulations address issues such as feeding, watering and sanitation. Under

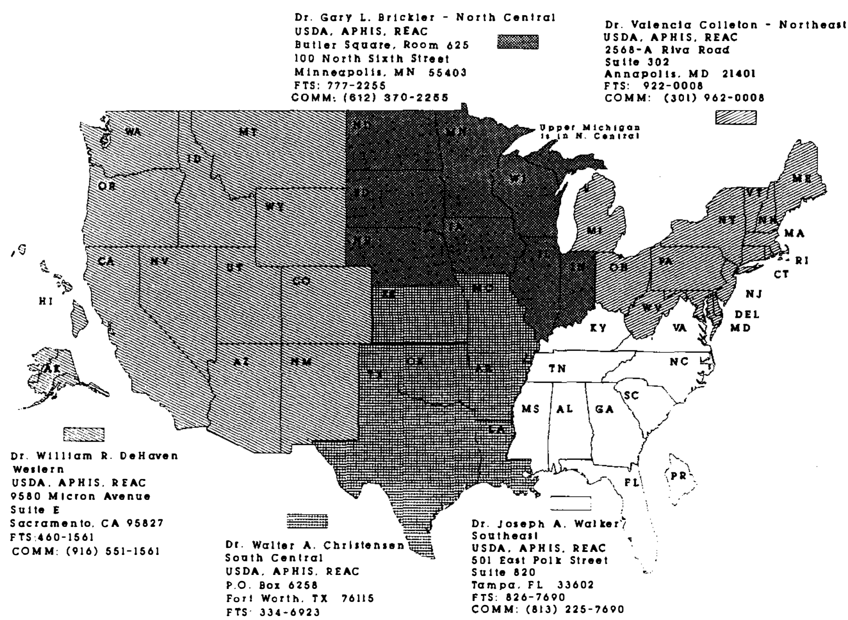

Figure 1. Animal care sector offices. Alaska and Hawaii are in the western sector; Puerto Rico is in the Southeast sector.

this section there are two additional provisions; the first mandating that adequate employee staffing be provided and second, that animals must be housed in compatible groups. Finally, the transportation standards provide instructions to both facilities and carriers/handlers as to the paperwork documentation required, the types of enclosures that are acceptable and in compliance with the Animal Welfare Act, and the duties and care that must be provided while in transport.

Trends in the Animal Welfare Movement

The Federal Perspective

The overall movement in the federal sector involved with animal welfare is toward greater sensitivity to the concerns of the public. In 1988, APHIS was reorganized. A new division called Regulatory Enforcement and Animal Care (REAC) was created to implement the AWA. Personnel assigned to the Animal Care portion of this division concentrate exclusively on animal welfare issues. Additionally, on June 4, 1990, APHIS announced its intention to regulate the care and maintenance of farm animals used in research and for exhibition.[13]

As issues surrounding animal welfare unfold and develop, it is easy to imagine that species formerly excluded from regulation, e.g., birds, laboratory rats and mice, are likely to become incorporated into the regulatory fold.

The Regulated Community's Perspective

The regulated community, e.g., zoos, aquariums and wildlife researchers, have begun to embrace the notions of animal welfare. The American Association of Zoological Parks and Aquariums (AAZPA) has provided APHIS with recommendations for standards for housing non-human primates in captivity. AAZPA is currently working on standards aimed at the maintenance of all other mammals commonly held in captivity. The participation of the regulated community is both enthusiastic and helpful. The federal government in concert with concerned individuals and associations can enhance the implementation of the Animal Welfare Act.

Conclusions

Public interest in issues surrounding animal welfare is growing. During the process of proposing its last set of animal welfare regulations, APHIS received over 12,000 comments from concerned individuals and entities. In 1990, APHIS answered over 20,000 letters from constituents concerned with animal welfare issues or the implementation of the Animal Welfare Act.

Several key federal agencies have moved toward recognition of animal welfare concerns. This has been demonstrated by the actions of FWS, which is attempting to respond to concerns raised by both researchers and the general public. NMFS is currently re-evaluating its role in animal welfare issues in light of the Marine Mammal Protection Act. Although much remains in the "gray" area in terms of wildlife involvement in the animal welfare movement, it does appear that the federal government and the regulated community are moving forward on the public's concern for animal welfare.

[13]55 Federal Register 12630, April 5, 1990.

Animal Rights Challenges to Bowhunting

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Introduction

Bowhunter numbers have increased from 0.5–2.5 million over the past 15 years as a result of increased numbers of deer (*Odocoileus virginianus*) (Southeastern Cooperative Wildlife Disease Study 1988), liberal hunting seasons and the advent of the compound bow. Participation and deer harvest rates have increased dramatically, mostly in response to rapidly growing deer herds around the country.

The growth of bowhunting has been associated with issues: competition between firearm and bow hunters; utility of bowhunting as a deer management tool, especially in residential areas; appropriateness of technological aids (compound bows, lighted sights, mechanical releases, and tree stands); and, more recently, wounding of game by bowhunters and related anti-hunting challenges. Managing these bowhunting controversies is made difficult by at least three conditions.

First, wildlife managers and agencies who must represent the wildlife resource as well as allocate recreational opportunity find themselves in the difficult role of mediating among other stakeholders and participating as an advocate of hunting as a management tool. Second, bowhunting issues are very complex and many stakeholders are involved. Third, data has not always been readily available on these issues to allow separation of opinions from facts.

This paper analyzes bowhunting issues related to anti-hunting challenges using an issue analysis framework model by Peyton (1984) which suggested that management of issues is enhanced if the stage of issue development and the status of three contributing factors are assessed. Issues may develop through latent, emerging, active and disruptive stages. The effectiveness of options available to the manager for resolving the issue varies with the development stage. Issues which can be identified at the *latent* and *emerging* stages can be dealt with through effective planning. At these stages, communication regarding the issue is primarily within stakeholder groups. Agencies may be able to avoid further development of the conflict. For example, changes in wildlife management programs or regulations may effectively reduce controversy surrounding the issues. Educational programs may alter public perspectives and/or behaviors and lessen potential for conflict. Public involvement activities can successfully increase communication, understanding and acceptance among potentially conflicting stakeholders.

At the *active* stage, stakeholder groups are communicating directly with the agency. Positions on the issue become rigid and high emotional levels make the issue more difficult to manage. At the *disruptive* stage, communication lines circumvent the agency. At least some of the stakeholders go to different authority (e.g., judicial or legislative powers) to seek resolution. When an issue reaches this stage, there is usually much conflict among the different stakeholders. This conflict may lead to further polarization which makes planning, education and public involvement more difficult. Also, all stakeholders must expend funds to prepare for court appearances. The outcome of disruptive issue stages will be less a function of wildlife management planning and more a result of the political and legal process.

The three contributing factors proposed by the model are: (1) the status of our science and technology to provide information, alternatives and assessment of risk; (2) the beliefs (perceptions of reality) held by stakeholders; (3) the values and priorities held by stakeholders. Issues vary in the relative contribution of each of these components and, thus, require different management strategies. In the anti-bowhunting issue, all three components contribute to the issue, however, the major cause of conflict is differing values and philosophy.

History of Anti-bowhunting

Though bowhunting was common in the 1950s and 60s, it was not considered a major part of herd management due to small annual harvests. However, with the growth in bowhunting, it has become an effective tool in assisting state agencies to manage deer herds. For example, in 1977, 45,000 West Virginia bowhunters harvested 2,531 deer. Ten years later, over 100,000 bowhunters took 19,742 deer. Similar growth occurred in many states. In New Jersey, 29 percent of the total deer harvest (48,178) was taken by 50,000 bowhunters (D. Burke, personal communication). In 1989, Michigan bowhunters took an unprecedented 96,700 deer, representing 21 percent of the 452,490 deer harvested (H. Hill, personal communication).

Burgeoning deer populations in urban and suburban areas have caused increased numbers of auto accidents (Blouch 1961, Bellis and Graves 1971, Langenau and Rabe 1987), damage to ornamental plantings (McDowell and Benson 1960, Carpenter 1966), hazards to airplanes (Iker 1983) and may pose risks to human or animal health where deer act as hosts for disease vectors (Spielman et al. 1985). Concerns over firearm safety have limited the actions of agencies responsible for regulating deer populations. In many cases safety reasons preclude the use of firearms and since alternative removal methods may not always be practical nor financially possible bowhunting has been suggested as a tool to remove the deer. Unfortunately, opposition to bow hunting has surfaced among anti-hunting organizations (Pacelle 1990), sometimes restricting management efforts. A recent set of deer management recommendations developed in Minnesota did not include bowhunting because of concerns over killing effectiveness and the potential for wounding and wasted animals (Minnesota Valley Deer Management Task Force 1990).

The first legal attack against bowhunting took place in 1973 at the Chincoteague and Eastern Neck National Wildlife Refuges in Virginia and Maryland, respectively. This case originally focused on shotgun hunting at the Great Swamp National Wildlife Refuge in New Jersey, but was later expanded to include bowhunting at the above two refuges. In this case, the Humane Society of The United States argued that hunting was inhumane and that the use of primitive weapons was contrary to principles of sound wildlife management.

In 1973, a hunt was planned at Great Swamp NWR, but several groups filed a restraining order because no environmental impact statement had been filed. No hunt was held that year. The impact statement was filed in 1974 and, over legal appeals, the hunt was held. In 1975, the Fund For Animals and other groups filed suit for a temporary injunction to prevent a hunt on Great Swamp NWR, claiming that it wasn't necessary for herd management, but was conducted merely for sport. Presently, bowhunting is conducted on all three refuges involved in this suit.

Occasional confrontations have occurred over the years. One notable example took place in Princeton Township, New Jersey, where firearm hunting was stopped in 1972. Deer/car collisions increased from 33 in 1972 to 196 by 1984 (Kuser and Applegate 1985), while adjacent townships with hunting saw only a 25 percent increase during that same period (Schneider and Kuser 1989). Other problems, such as farm crop damage, garden and shrub damage, increased incidence of Lyme Disease, the tree damage on nurseries (Schneider and Kuser 1989) led to the formation of a deer committee to seek solutions. Based on a poll of residents, the committee recommended a public education program and a controlled firearms hunt. Bowhunting in the township has remained open with harvest steadily increasing through 1989 while road kills peaked in 1986, then declined (Schneider and Kuser 1989).

In recent years, anti-hunters have tested state hunter harassment laws by interrupting bow and gun hunts. In 1990, there were bowhunter harassment incidents in California, Indiana, Kentucky, Maryland, Nebraska, New York, Ohio and Pennsylvania, to mention a few. Two of the most publicized incidents occurred at McBee Beeshers Wildlife Management Area in Maryland in 1989 and 1990, and Mason Neck NWR in Virginia in 1989 and 1990. Both incidents led to anti-hunter arrests and much publicity, and the bowhunts are continuing.

Anti-hunting efforts have also been aimed at small, urban/suburban state parks with growing deer herds. One good example of this situation occurred at Rock Cut State Park in Rockford, Illinois, where an estimated 80 deer per square mile caused problems typical of high deer numbers in small, protected, urban areas. Over a two-year period, controversy led to proposed anti-hunting legislation, hearings, public outcry and threats to the budget of the Illinois Department of Conservation. Anti-hunter concerns centered around several items; (1) that hunting would lead to a higher deer population by stimulating reproduction, (2) that bowhunting was ineffective and inhumane, and (3) that the Department of Conservation did not have an exact population count of deer in the 2,743-acre park. In 1990 public hearings led to a compromise solution; a bowhunt was followed by a firearm kill by marksman in an effort to lower deer numbers. Anti-hunters supported the use of marksmen, but opposed the bowhunt.

In 1989, a group called Wildlife 2000 opposed the spring bear hunt in Colorado (bow and firearms). They felt that too many lactating females were harvested and also questioned the ethics of hunting over bait. The result was that the Colorado Wildlife Commission shortened the spring bear season from April 1-Jun 15 to April 1-May 15, thus, effectively eliminating the spring bow season. In September 1991, the Colorado Wildlife Commission will set a three-year structure for bear hunting. Any changes will be made at that time.

Animal rights groups have also attacked bowhunting in Rhode Island, beginning in the mid 1980s and continuing today. The most recent approach has been to get a bill passed through the state legislature to ban bowhunting, and a legislature-appointed commission is now deliberating this issue. A bill also was introduced under a safety concern that would limit all hunting within 1,000 feet (previously, 500 feet) of a road or occupied building. Such action would eliminate hunting on 50 percent of state wildlife management areas (J. Myers personal communication). Also, the anti-bowhunting issue addressed by the legislative commission has expanded to include other forms of hunting (J. Myers personal communication).

The most publicized anti-bowhunting incident occurred in California in 1990, when the black bear archery hunting season was stopped. The California Environmental Quality Act requires the Game and Fish Department to justify each hunting season by making a full disclosure of all effects of any hunt via an environmental impact statement. The Fund For Animals challenged this document for the black bear bow season, and the court ruled against the game department based on an inadequate review of wounding literature and consideration of the welfare of individual animals. That ruling is being appealed, and the state game agency has filed complete documents to reinstate the bear bow season in 1991. Almost certainly, other anti-bowhunting bear hunting situations will arise in 1991.

On February 18, 1991, a Minnesota animal protection group—Friends of Animals and Their Environment—announced that it will attempt to get legislation passed that would ban bowhunting for deer in Minnesota, because it is inhumane and wasteful. If that fails, they indicate they will file a suit to ban bowhunting utilizing state laws to prevent cruelty to animals.

Today the anti-bowhunting issue is basically a smaller segment of the anti-hunting issue. Bows apparently are targeted because they are viewed as primitive and lacking the ability to kill in a humane fashion. It is apparent that anti-bowhunting activity will continue and that other planned expansions of bow and firearms seasons will come under heavy scrutiny.

Issue Analysis

Stage of Development

The anti-hunting controversy in general, and bowhunting issues in particular, are rapidly becoming disruptive issues. In large part, this is a predictable result of the anti-hunting stakeholders being outside the traditionally recognized constituency of fisheries and wildlife agencies. Anti-hunting groups have perceived the wildlife management process to be closed to them and thus have sought other authorities to represent their interests. One example is the approach taken in california where anti-hunters used the courts to stop the archery black bear season. Other states have experienced similar instances where hunting regulations have been challenged by referendum, court action or other authorities (e.g., Lautenschlager and Bowyer 1985). The trend can be expected to continue as anti-hunting interests find new ways to circumvent and influence the management processes of the state and federal agencies.

Components of Bowhunting Issues

Findings of several researchers suggest that the "anti-hunting" group is actually comprised of several stakeholder groups with different primary concerns (Shaw 1977, Kellert 1978). Hunting may be opposed on the basis of concerns for public safety, matters of trespass, inconvenience or disturbance, concern for animal rights (moralistic value), concern for animal welfare (humanistic value), and/or ecological concerns. Of course, individual participants may be motivated by a range of these values and concerns. Alliances may be formed among these groups in their anti-hunting efforts, often causing the values to become entangled and confusing to managers, non-hunters and even the stakeholders involved. For example, animal rights issues and environmental issues are intermixed by the media and others, yet there are important contrasts in basic values and perspectives advocated by each of these (Callicott 1989). Animal rightists value the rights of individual members of animal populations. In extreme forms, protection of individual animal rights may take precedent over concern for the ecological system. (The name of the animal welfare group seeking legal action in Minnesota, "The Friends of Animals and Their Environment," appears to be an attempt to embrace both philosophies). An environmental philosophy, however, places priority on the welfare of the ecological system (e.g., populations and communities) and recognizes the dispensable role of the individual in a healthy ecosystem. An environmental argument against hunting would be based on undesirable manipulation of ecosystems to produce harvestable populations of game species, or on fears of overharvest of species (e.g., bear). At least in theory, conflicts between environmental concerns and bowhunting offer opportunities for resolution. Alternatively, the animal rightist is philosophically in conflict with bowhunting regardless of the status of the hunted population or ecological, social or other impacts. Few opportunities appear to exist for resolving bowhunting issues so that values of animal rightists and hungers are not compromised.

Important differences also exist between the animal rightist and the anti-hunter primarily motivated by concern for animal welfare. The latter may not assign moral rights to non-human species, but objects to hunting when animal suffering or discomfort are unnecessarily inflicted. The animal rightist would object to hunting mortality under any condition. Modifications in hunter behavior and/or regulations, and public education programs offer opportunity for increasing acceptance of bowhunting among those concerned for animal welfare but will not impact strong animal rights advocates. Schmidt (1990) makes a convincing differentiation between animal rights and animal welfare and urges the wildlife profession to focus on those interested in animal welfare.

One advantage of maintaining a distinction among the many values in anti-hunting issues is to be able to communicate these clearly to the non-hunting public who have not joined the ranks of either hunters or anti-hunters. Non-hunters appear to be concerned more for environmental, safety and animal welfare reasons than for moralistic rights of animals (Rohlfing 1978). If agencies approach the bowhunting controversy from this perspective, the large non-hunting public will be able to evaluate anti-hunting controversies more accurately by maintaining clear distinctions among the values and positions involved in the issues.

Profound differences in values and philosophies are confounded by differences in perceived "facts" (beliefs). The beliefs which stakeholders hold are applied to their values to evaluate the bowhunting issues and form attitudes about them. Much of the debate in this controversy centers on wounding rates, the fate of wounded animals, pain experienced by game animals, the utility and necessity of hunting as a management tool, the economic benefits of hunting activities, etc. Some of this controversy exists because information has not been accurately communicated to all stakeholders, however, for other aspects (e.g., wounding rates) data exist, but may not be conclusive. To this extent and for the purposes of refining our management programs and communicating with non-hunters about the anti-hunting controversy, efforts to improve our scientific understanding of the issue is worthwhile. However, it must be recognized that even if all stakeholders agreed on the factual basis (e.g., the actual rate of wounding and fate of wounded game), the value conflicts in the issue would be more clearly defined, but the issue would not be resolved. Conflicts of science and fact are often the focus of skirmishes among stakeholders, but the primary goal of the process must be to gain acceptance and understanding of conflicting values.

The utility of bowhunting, the safety of bowhunting and the occurrence of wounding deserve further review here since these impact on the human safety, animal welfare and animal rights values which appear to be the primary issues in current bowhunting controversies.

Safety. Bowhunting's good safety record has made it a choice for deer herd control in some suburban/urban situations. Where high deer numbers threaten habitat and endanger human lives via automobile accidents, bowhunting is being utilized for deer herd control. Statistics for 1989 show that during an estimated 30 million many days afield (L. Smith personal communication), 2.5 million bowhunters had only 21 accidents; 3 of these were fatal (Hunter Education Association 1989). Nonparticipants were not involved in any bowhunting accidents.

Thus, when deer numbers necessitate moderate reductions, bowhunting may well be an answer. Many smaller areas combine the use of the bow for harvest with a bowhunter education course to fully ensure that safety precautions are taken. Requiring participants in selected-area bowhunts to take such a course may also help to allay fears of the nonhunters who live in the area. The course that is used is the 10-hour International Bowhunter Education Program which is available in all states and Provinces and is mandatory in New Jersey, New York, Maine, Montana, Rhode Island and Nova Scotia.

The Utility of Bowhunting. Bowhunting also plays a major role in deer herd management in larger areas as well. In New Jersey, bowhunters take 28.7 percent of the total deer harvest (Table 1). In Michigan, bowhunters take 21.4 percent of the total harvest; in Indiana, they take 20.0 percent; and in Maryland, they take 17.3 percent (Table 1). In many states bowhunters take over 10 percent of the total deer

Table 1. Bow and gun deer harvest for selected states.[a]

State	Year	Bow harvest	Gun harvest	Bow percentage of total harvest	Number of bowhunters
Indiana	1990	17,775	70,981	20.0	72,000
Iowa	1989	11,857	87,855	11.9	34,745
Maryland	1989	7,988	38,305	17.3	41,553
Michigan	1989	96,700	355,790	21.4	275,000
Minnesota	1989	9,307	129,511	6.7	66,668
Missouri	1989	10,966	157,415	6.9	83,500
New Jersey	1990	13,826	34,352	28.7	50,000
New York	1989	12,770	169,109	7.0	159,096
Ohio	1989	4,690	76,117	5.8	80,000
West Virginia	1989	16,217	129,350	11.1	100,000
Wisconsin	1989	46,400	310,700	13.0	210,900

[a]Data obtained by personal communication with J. Olson (Indiana), L. Gladfelter (Iowa), L. Fromm and K. D'Loughy (Maryland), H. Hill (Michigan), J. McAninch (Minnesota), L. Hansen (Missouri), D. Burke (New Jersey), W. Jones (New York), D. Watts (Ohio), W. Santonas (West Virginia), and K. McCaffery (Wisconsin).

harvest. The quiet nature of the sport allows large numbers of bowhunters to safely take to the field with few interactions with landowners, firearm hunters or other recreationists.

Wounding. The frequency and fate of wounded game is an important aspect of the bowhunting issue because of the prominence of animal welfare and animal rights values, although there does not seem to be a biological basis for concern.

Anti-hunters believe that bowhunting produces a large number of animals that are wounded and left to suffer pain and a lingering death. Still further, they believe that archers are more brutal to animals because of the inaccuracy and lack of killing power of the bow.

Bow wounding literature is incomplete and difficult to interpret for several reasons. First, there is the problem of no standardized definitions for terms and the associated understanding of the fate of "wounded" deer. Scientific studies, technical reports and popular literature utilize such terms as "cripple loss," "wounding loss," "wounding rate," "wounded" and "crippled" as being synonymous. McCaffery (1985), in a paper on "crippling" semantics, provided some insight into the proper definitions for the commonly used wounding terms. The definitions he proposed were:

- *Wounded:* Animals that have been injured in some fashion by hunting equipment and their fate is unknown. Actual hits may range in severity from superficial (hair, antlers, flesh, etc.) to more severe wounds.
- *Unretrieved Hunting Mortalities:* Any animals dying from wounds and not found by the hunter. This would include terms used in the literature such as unrecovered kills and illegal kills.
- *Abandonment:* Any animal killed, found by the hunter and abandoned.

Even though McCaffery (1985) summarized the problem, improper use of terminology still goes on today. K. Mayer (personal communication) suggested (in his summary of bow wounding for the environmental document needed in the California bear-bow legal dispute) that the term ''crippling'' infers to make disabled, lame or deficient. Mayer noted that in biological terms ''crippling'' means to render the animal physically deficient, hence highly susceptible to death as a result of the deficiency. He pointed out that there are no studies to confirm the number of ''crippled'' animals, though some studies show that many archery wounds are apparently superficial, thus not life threatening (Nettles et al. 1976). He agrees that the use of different terms in all literature makes comparisons among studies difficult and this has led to inaccurate conclusions by stakeholders who attempted to introduce such literature into court proceedings.

Another reason the wounding literature is incomplete is that obtaining such data is extremely difficult. The two most common approaches involve hunter interviews or ground searches, and both methods have limitations (Langenau and Aho 1983, Lohfeld 1979). Usually such studies are conducted in special areas (e.g., parks or fenced military areas) and results may only apply to a special group of hunters and may not be extrapolated to all hunting populations. Often there are special conditions utilized for the hunt on such areas, and this also confounds the data. Still further, hunter interview methodology does not usually allow a determination of the fate of wounded animals.

Ground search studies require tremendous labor, and even then all dead deer may not be found, wounded deer may leave or enter the study area, or die after the search. There are other problems with wound studies. There is no way to differentiate superficial wounds from serious, debilitating wounds. Once dead deer are found it may be impossible to determine what caused the death.

Benke (1989) provided many personal accounts of bow wounding and suggested that wounding rates for deer were 10–100 percent. Pacelle (1990) adapted such data and indicated that 80 percent of unretrieved animals died from arrow wounds. However, empirical studies show a wide range of data on unretrieved hunting mortalities. Ground search studies showed bow wounding losses of 9 percent (Herron 1984), 11 percent (Lohfeld 1979) and 50 percent (with a sample size of eight animals) (Downing 1971). In a controlled shooting situation, 30 percent of African big game animals hit with broadheads were unretrieved (Ludbrook and Tomkinson 1985).

Questionnare and interview studies showed 12 percent of Iowa bowhunters felt they wounded a deer (Gladfelter et al. 1983), 62 percent of deer believed hit by bow hunters on a special situation hunt in Michigan were not retrieved (Langenau 1986), while McPhillips et al. (1985) noted that the perceived reported wounding rate as a percentage of the total deer harvested in South Dakota was 48 percent. In February 1991, the California Fish and Game Department conducted a complete review of the literature and concluded that ''archery wounding does not appear to be either biologically significant or inhumane'' (K. Mayer personal communication). Obviously, beliefs on this issue differ considerably among stakeholders.

Both ground search studies and hunter interviews or questionnaires have reliability and validity problems and, thus, results must be interpreted cautiously. We need more studies of both types, under generalized conditions, before we can reach final conclusions on this topic. Obtaining such data will be extremely costly and will take extended periods of time. In conclusion, wounding losses are not large enough to affect a herd, they are a social problem and not a biological problem, and education is the way to solve this rather than a ban of bowhunting.

Summary

While space does not permit an exhaustive analysis of the many issues and stakeholders involved in the bowhunting controversies, the principles have been illustrated. As further analysis occurs it will be important to identify all stakeholders in an issue including unorganized stakeholders, other types of hunters, anti-hunters, property owners, professional wildlife managers, legislators, commercial interests and non-hunters. Involving a broad array of stakeholders will provide a more representative process and balance the intense activity of some stakeholders. Further, these groups must be understood well enough to be able to segment them on important characteristics such as the primary value concerns or information levels. This allows the management agency to identify the most promising investment of resources in a broad plan of activity including research, public information programs and public involvement which targets specific dimensions of the issue and associated stakeholders.

For example, citizens who oppose particular applications of bowhunting must be segmented based on the nature of their concerns (e.g., safety, trespass, animal welfare, animal rights). Animal rightists are not likely to be influenced by new information regarding wounding rates, economics or benefits of bowhunting since they have clearly defined the issue in terms of animal rights values and philosophy, and their beliefs merely support that position. Non-hunters, however, respond to a broader array of values and concerns and often will evaluate their positions in the presence of new information.

Implications

Several implications of the analysis have already emerged:

1. Without a strong educational response which reflects the more ecological and utilitarian values regarding wildlife resources, increasing numbers of non-hunters will continue to adopt the orientation of anti-bowhunters.
2. Wildlife managers can expect that the issue will become more disruptive and involve more legislative and judicial activity, since that is the accepted procedure for getting values and philosophies recognized and established in our society. In this and other wildlife issues, we should integrate methods to deal with the value conflicts so that stakeholders better understand and respect differing value positions.
3. Specific needs for scientific research and information can be identified. For example, the management community should standardize terms associated with wounding phenomena and increase research to better monitor wounding and its consequences. However, attempts to manage the issue by responding soley to the need for more science or information transfer will fail to lessen the issue intensity.

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Ideological Conflict Between Animal Rightists and Wildlife Professionals over Trapping Wild Furbearers

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Introduction

During the last 60 years, the wildlife profession has witnessed an expansion of animal rights organizations which focused public attention on the issue of wild furbearer trapping (Barrett et al. 1988). With campaigns that take advantage of political opportunities and people's emotions (Gentile 1987), they promulgated the view that wild furbearer trapping was cruel and unnecessary for wildlife management or human requirements (Barrett et al. 1988). Animal rightists repeatedly introduced anti-trapping bills in various legislations (Gentile 1987); they also presented their views in international forums such as the 1983 Convention of International Trade in Endangered Species (CITES) and the 1987 meeting of the International Union for the Conservation of Nature (IUCN) (Barrett et al. 1988). The controversy raised by animal rightists is now draining the resources of wildlife agencies and robbing them of progress on important wildlife research and management projects (DeStefano 1987).

The objectives of this paper are: (1) to review the philosophy and allegations of animal rightists and to compare them to the philosophy and practices of furbearer managers; and (2) to address the animal rightists' concerns in relation to new developments in humane traps and trapping methods.

The Animal Rightists and Their Philosophy

In the past, the anti-trapping movement was divided into animal rightists and welfarists. Most animal rightists believe that animals are entitled to the same basic legal rights of human beings (Singer 1975, Regan 1985). These rights include not being killed, eaten, used for sport or research, or subjected to abuse. Animal rightists belong to anti-vivisection societies, non-euthanizing and non-killing organizations. Some animal rights groups are abolitionists and condone or encourage illegal actions, civil disobedience or even violence (Anonymous 1989, MacDonald 1989). Animal welfarists are concerned about the treatment of animals and they wish to reduce pain and suffering (Standing Committee on Aboriginal Affairs and Northern Development [SCAAND] 1986).

It is sometimes difficult to distinguish between animal rightists and welfarists. Generally, animal rights groups do not publicly present their case on the basis of whether an animal should be killed at all (SCAAND 1986). Seemingly, as part of their strategy, animal rightists have infiltrated established animal welfare organizations and pushed them into more radical positions. This happened recently to the Toronto Humane Society (Herscovici 1989). Some animal welfare groups have also adopted a more radical position because they are competing with the animal rightists for the same pool of public funds (Howard 1986, Herscovici 1989). Finally, some welfare organizations have simply decided to redirect their course of action. This is the case of the Alberta Society for the Prevention of Cruelty to Animals (SPCA). By working with the fur industry in trap development and trapper education programs, Burns (1990) felt that the society was being used to legitimize the industry as a whole. The society is now opposed to the trapping industry. In this paper, we consider that welfare organizations which do not restrict their philosophy to the issues of pain and suffering in trapping are aligned with animal rightists.

The Wildlife Managers and Their Philosophy

Leopold (1933) defined wildlife (game) management as "the art of making land produce sustained animal crops of wild game for recreational use." This tenet is still valid today. However, during the last 50 years, it has evolved and become more comprehensive because of a better understanding of biological principles, wildlife populations and habitats (McCabe 1985), and a change in societal concerns and priorities (Dassman 1966, Proulx and Barrett 1989a). Traditional harvest-oriented management was replaced by a new thinking that includes the concerns of nonconsumptive users as well as those of harvesters (Scheffer 1976). Today's wildlife manager is a spokesman for wildlife, a custodian of a variety of public interests and a key element in the decision-making process regarding land use (Gilbert and Dodds 1987).

The management of furbearers involves the manipulation of their populations and their habitats (Wolfe and Chapman 1987). Fur trapping is a population management tool based upon the rationale that animals can, and often do, produce many more offsprings than their range can support. Trapping aims at that surplus of animals which cannot be stockpiled indefinitely (Todd 1981).

Anybody who manipulates a population or its habitat practices some form of wildlife management. However, in this paper, we refer to wildlife management practised on a scientific basis (*see* Wolfe and Chapman 1987). Wildlife managers are professionals, usually wildlife biologists, with demonstrated expertise in the art and science of applying the principles of ecology to the sound stewardship and management of wildlife resources and their environments (Yoakum and Zagata 1982, Kennedy 1985).

Unreconcilable Philosophies

Animal rightists see wildlife management as an activity producing a surplus of desired species to maximize the trapper's harvest (Defenders of wildlife 1984). They believe that wildlife management does not respect the right to life of individual animals in a population (Decker and Brown 1987). Animal rightists also believe that wildlife management is unnatural and unwarranted in wilderness regions due to the "balance of nature" (Todd 1981, Howard 1986).

The animal rights movement is particularly disconcerting for most wildlife professionals because it opposes not only the activities that management makes possible (e.g. hunting and trapping) but also the underlying assumptions and precepts upon which the profession has been based (Decker and Brown 1987). Wildlife managers believe that human rights are not transferable to animals (Guthrie 1967, McCloskey 1979) but recognize that humans are responsible to sustain the long-term welfare of wildlife (Proulx and Barrett 1989a, The Wildlife Society 1990). They focus their attention on the animal population rather than the individual. Wildlife managers believe that human beings are part of nature and they are a natural factor in food chains, energy cycles and all of the dynamics of a living community (Dassman 1966, Howard 1986). The total prohibition of harvest by man would be an unnatural form of management in the highly modified environments in which we live (Boggess 1982). The 'leave it to nature' philosophy of the animal rightists is irresponsible (Howard 1986) and furbearers cannot be considered in isolation, even in wilderness regions, due to multiple land-use precepts (Todd 1981). Wildlife managers try to avoid the violent fluctuations in animal numbers associated with the ''natural balance of nature.''

The philosophies of animal rightists and wildlife managers are unreconcilable. Animal rightists raise serious questions about the necessity of trapping and the quality of professional wildlife management. Their allegations endanger wildlife management programs (Proulx and Barrett 1989a) and deserve our attention.

Is Trapping Necessary?

Animal rightists believe that wild furbearer trapping exists solely for luxury and vanity (Goddard 1986), is unnecessary for wildlife management or human requirements (Defenders of Wildlife 1984) and is of little economic importance (Smith 1988). We do not agree with their allegations.

Trapping is necessary because of economic concerns. Over 500,000 people are directly involved in trapping in North America (Todd and Boggess 1987). In Canada alone, 50,000–60,000 trappers are aboriginal people (SCAAND 1986). The continental fur industry is worth millions of dollars and is especially important to aboriginal people as a source of money and food (Fox and Ross 1979, Woods 1986) and for clothing and handicraft production (Todd and Boggess 1987).

Trapping is necessary because of socio-cultural concerns. Many aboriginal people prefer subsistence lifestyles to the regimentation of wage employment or the emptiness of social assistance, a preference that has immeasurable cultural and social significance (SCAAND 1986, Todd and Boggess 1987). Enjoyment of the outdoor experience is a strong motivation for aboriginal (Fox and Ross 1979) as well as for non-native people (Krause 1989a). Nowadays, trapping is an important recreational activity (Todd and Boggess 1987).

Trapping is necessary because of biological concerns. Habitat deterioration due to over-exploitation by beaver (*Castor canadensis*) (Patric and Webb 1953, Knudsen 1962) or muskrat (*Ondatra zibethicus*) (Errington et al. 1963) can be avoided through trapping. The removal of surplus animals reduces competition among the animals for food and cover, and increases the chances of survival for the remaining population (Payne 1980). The ecological benefits associated with the control of these populations include the perpetuation of habitats important to other species (Brown and Parsons

1979, Knudsen 1962). Trapping is necessary to control wildlife predators or pests when they are causing economic damages or when they are impacting heavily on other wildlife (Berryman 1971). Trapping is also used to hold the spread of wildlife diseases in check. Rabies annually costs millions of dollars for human treatment and vaccination of pets (Rosatte 1987) and can result in long-term suppression of animal numbers (Voigt 1987). Intensive trapping programs can reduce infected populations and, consequently, the spread of the disease (Bigler et al. 1973, Gunson et al. 1978, Voigt 1987). Trapping is an efficient method to remove nuisance animals which can transmit parasites to humans and other animals (Fish and Daniels 1990).

Trapping is necessary because of conservation concerns. Trappers' license fees and voluntary contributions help fund wildlife management programs (Fritzell and Johnson 1982, Allen 1990). As a user group, trappers represent a political force which can convince administrators to protect wilderness areas such as marshes and wetlands. The maintenance of fur trapping may be vital for the perpetuation of natural habitats which, otherwise, could be transformed by industrial and urban developers (Herscovici 1985).

Trapping is necessary because of research needs. The coexistence of human beings with other species and the development of sound management programs greatly depend on good knowledge of wildlife species. Trapping provides basic data on the health and dynamics of furbearer populations. Trappers are valuable nature observers and can bring subtle habitat changes to the attention of wildlife professionals.

Trapping is necessary. It is a source of income, a way of life and a recreational activity. It is an important tool to control furbearer populations for their own sake and for the benefit of human beings. Finally, trapping plays an important role in the maintenance of wildlife management programs.

Furbearers and Fur Trapping: Are They Managed?

Animal rightists preach that professional wildlife management is unsound and that managers are more interested in pelt primeness than in the welfare of wildlife populations. In their view, reliable data on furbearer populations and the impacts of trapping are lacking and fur trapping is not properly managed (Defenders of Wildlife 1984, O'Sullivan 1989).

The animal rightists' allegations fail to recognize the complexity of the furbearer manager's job. The objectives of furbearer management programs in North American are similar from one jurisdiction to the other (*see* Anderson 1987, Hamilton and Fox 1987, Linscombe 1987). In general, the programs aim to: (1) monitor the biological status of each species, (2) maintain viable populations of each species, (3) optimize the harvest of the furbearer resource when furs are in prime, and avoid overexploitation, (4) minimize animal damage, and (5) provide the public with recreational, economical, and ecological benefits.

Furbearer managers of most jurisdictions are responsible for 15–20 species found at different trophic levels and in a variety of habitats. In order to meet the objectives, managers have acquired extensive knowledge about the life history and ecology of furbearers (*see* Chapman and Feldhamer 1982, Sanderson 1982, Novak et al. 1987). Management programs typically involve many activities such as the analysis of harvest trends and the study of trapper-donated carcasses for the determination of the sex and age ratios of the populations, and an assessment of the reproductive and physical conditions of the animals.

Managers pay particular attention to population trends of furbearers. Harvest estimates based on pelt registration, trader transaction reports, export permits, furtaker reports and sample surveys are used by all wildlife agencies. Wildlife managers concurrently use other techniques to determine the relative abundance of species: samples of signs (Sargeant et al. 1975, Proulx and Gilbert 1984, Thompson et al. 1989); roadkill surveys (Lehman and Rolley 1987); scent stations (Linhart and Knowlton 1975); night-lighting (Rybarczyk et al. 1981); intensive capture/recapture programs (Sanderson 1951, Proulx and Gilbert 1983); and questionnaires (Lemke and Thompson 1960, Groves 1988).

Trapping seasons protect breeding stocks and ensure that harvests occur when pelts are sufficiently prime (Novak 1987). Quotas are used to prevent overpopulation and overharvesting, and to eliminate inactive trappers from productive traplines (Novak 1987). Jurisdictions have the ability to regulate methods of harvest to protect non-target species (Melchior et al. 1987). Individualized quotas and trapline registration encourage trapper responsibility (Novak 1987).

Much research and management efforts have been directed at furbearers with high pelt prices. Pelt registration is used to determine the number of animals harvested and to better control illegal trapping (Erickson 1982, Novak 1987). Lynx (*Felis lynx*) may be protected when at the bottom of their cycle and trapped only when at the top or abundant stage of their cycle (Brand and Keith 1979, Novak 1987). In the past, several jurisdictions have stopped marten (*Martes americana*) trapping because too many animals were being taken. Trappers are also asked to set aside part of the trapping territory as a refuge (Blood 1989). When furbearer populations are small or in decline, selective harvest is recommended (Strickland et al. 1982) and transplant programs may be carried out (Berg 1982). Wildlife agencies also invest in the creation of wildlife refuges and land management programs for the sake of furbearers and non-game species (DeStefano 1987, Linscombe 1987).

Wildlife managers recognize the limitations of their methods (Erickson 1982). It still happens that wildlife management practices are applied on the basis of trial and error. Wildlife managers must frequently rely on harvest information for an after-the-fact analysis of furbearer populations (Hubert 1982). However, every year, researchers are providing new information which improves management programs. Mathematical models and simulations, and the implementation of computerized fur harvest data systems are also used to predict population changes and harvest fluctuations. Furbearer managers have established a good communication network and regularly meet in national and international workshops to exchange ideas.

The opinion that animal rightists have of wildlife managers often is inferential and prejudicial. For example, government budgets do not adequately address the needs for expanded resource management programs (Fritzell and Johnson 1982, Slough et al. 1987) and wildlife agencies must rely on revenues from licence sales. Because of this dependence, the integrity of wildlife managers is being questioned by animal rightists (Goodrich 1979, Defenders of Wildlife 1984). Animal rightists forget that wildlife managers are professionals with a code of ethics (The Wildlife Society 1986). In the past, furbearer managers have taken corrective measures that have conflicted with trappers' opinions, to improve their management programs and ensure the future of furbearer populations (*see* Slough et al. 1987).

We believe that, overall, furbearers and fur trapping are properly and professionally managed.

Humaneness in Trapping

Although the real intentions of the animal rights groups are to ban trapping, these organizations focus public attention mainly on the issue of humaneness. Animal rightists view trapping as a cruel activity employing antiquated technology. They believe that the fur industry is not humane, a humane trap is an elusive dream and humane trapping research is simply a public relations tool (Goddard 1986, O'Sullivan 1989, Burns 1990).

A basic problem associated with the cruelty issue in trapping is that the concept of humaneness never was properly defined. What is a humane trap? What is a humane death? The Random House College Dictionary defines "humane" as "characterized by tenderness, compassion, and sympathy for men and animals." Animal rightists consider that the combination of the words "humane" and "trap" is incompatible (Burns 1990). On the other hand, when one considers that some animals experience slow deaths because of debilitating injuries or diseases (Todd et al. 1981, Proulx 1989), many injurious traps could still be perceived as more humane than nature itself. The Federal Provincial Committee for Humane Trapping (FPCHT 1981) defined a "humane death" as "a death during which an animal suffers minimal distress. This may be achieved by rendering the animals unconscious and insensitive to pain as rapidly as possible with inevitable subsidence into death." O'Sullivan (1989) found that definition too broad and all-encompassing. Obviously, depending upon the criteria used, many traps could be classified as humane according to FPCHT's (1981) definition. The words "minimal" and "as rapidly as possible" may be interpreted differently among people and cultures. The period of time to irreversible unconsciousness has been changed over the years spanned by the FPCHT's (1981) work (Proulx and Barrett 1988). At first a 10-minute period was judged acceptably humane. However, in subsequent work, an effort was made to reduce this time period to what could be achieved practically and, with the result of kill threshold studies (minimum striking and clamping forces necessary to render an animal unconscious within a specified period of time) with anaesthetized animals, FPCHT (1981) eventually adopted a three-minute criterion for irreversible loss of consciousness.

Canada is the only country so far to have established national standards for specifications and performance of killing-type traps (Barrett et al. 1988). The Canadian General Standard Board (CGSB, 1984) adopted FPCHT's (1981) kill thresholds with a three-minute period of time to unconsciousness (Dodd 1988). On the basis of this standard and FPCHT's (1981) work, a research team, located in Vegreville, Alberta, tested traps in a series of sequential steps. The researchers considered a killing device to be humane if, at a 95 percent level of confidence, it would render >79 percent of animals captured on traplines unconscious within three-minutes. In order to meet such performance, a trap must: (1) mechanically rate above the CGSB's (1984) kill threshold line for the species studied (Cook and Proulx 1989a); (2) place ≥5/6 animals in preferred strike locations (approach tests in enclosures) (Proulx et al. 1989b); (3) render ≥5/6 animals immobilized with ketamine irreversibly unconscious within three minutes (pre-selections tests) (Proulx et al. 1989b); and (4) pass kill tests in enclosures by rendering 9/9 (or 13/14, or 18/20 . . .) animals irreversibly unconscious within three minutes (Proulx et al. 1989a). Afterwards, the trap is tested on traplines to once more evaluate its ability to properly strike and humanely kill the animals (Barrett et al. 1989). This sequential testing is the most discriminating process known in the search of humane traps (Proulx and Barrett 1989b).

Since 1985, we mechanically tested more than 60 traps intended for marten, mink (*Mustela vison*), muskrat, raccoon (*Procyon lotor*), fisher (*Martes pennanti*), red squirrel (*Tamiasciurus hudsonicus*), beaver, arctic fox (*Alopex lagopus*) and lynx (Proulx and Barrett 1989c, Proulx 1990). Most commercially available trapping devices rated below CGSB's (1984) kill threshold values (Proulx and Barrett 1988, Proulx 1990). However, the research was successful at improving the striking and clamping forces in traps (Proulx and Barrett 1988, Cook and Proulx 1989b). From 1985–1990, the research team developed several humane trapping systems for marten (Proulx et al. 1989a, Proulx 1990), mink (Proulx et al. 1990, Proulx and Barrett 1991), fisher (Proulx and Barrett 1989c), and arctic fox (Proulx 1990). Gilbert (1989) developed a killing trap for beaver in the same manner. Proulx and Barrett (1990) also showed that spring-powered neck snares could be used to quickly kill red fox (*Vulpes vulpes*) if a reliable set was developed to constantly capture the animals by the neck.

There are no standards for live-holding devices. However, Englund (1982) examined the carcasses of red foxes captured in different restraining devices and noted that the Swedish footsnare caused very few dental and limb injuries to the animals. Tullar (1984) introduced a limb damage score that was later modified by Olsen et al. (1986, 1988). With this system, Olsen et al. (1988) showed that the great majority of red foxes and coyotes (*Canis latrans*) captured in padded foothold traps did not suffer serious injuries (i.e., joint dislocation, broken bones and amputations). Onderka et al. (1990) also showed that the padded foothold trap and the Fremont footsnare were markedly less injurious than conventional steel leghold traps. In a simulated environment, Proulx (1990) showed that, at a 95 percent level of confidence, the EGG trap could be expected to hold >79 percent of raccoons captured on traplines without serious injury. Many ecological studies have also shown that properly monitored box traps can be used to live-capture small furbearers without serious injury (deVos and Guenther 1952, Proulx and Gilbert 1983).

Recent research work has clearly demonstrated that there were traps that met the highest standards in humane trapping. Yet the controversy continues. What are the motivations and perspectives that keep the humane issue in the forefront of the trapping controversy?

We believe that the fur industry and the agencies funding the trap research program have not adequately informed the public about the humane issue and the new trapping technology. There is no motive for animal rightists to inform the public about the development of humane traps; furthermore, they do not acknowledge that a trap can be humane! Therefore, interested parties must assume responsibility for public education and inform people who are not committed against trapping. Such education should be part of a massive and innovative public relations program that uses all the media and all the public relations expertise available (Todd 1980).

The humane trapping controversy persists also because some wildlife biologists have adopted an uncompromising defensive position in the face of the anti-trapping movement (Proulx and Barrett 1989a). While it is known that steel leghold traps cause serious non-lethal trauma to animals (Olsen et al. 1988, Onderka et al. 1990), some wildlife biologists still maintain that they are efficient humane traps. There are also trappers who reject new technology. Past humane trapping research programs had to meet the requirements of the fur industry, e.g., the trap must have a weight and size similar to those of the leghold trap, it must be useful for a wide range of species, it must be safe, cheap and easy to set and manufacture (Drahos 1952). Proulx and Barrett (1989a) believe that it is ludicrous to expect that humane traps will consistently have all the attributes of the steel leghold trap. Trappers must make compromises if they want to continue their activities. Krause (1989b) recognized the humaneness of the C120 Magnum trap for marten and mink (Proulx et al. 1989a, 1990) but rejected the trap on the basis that it was stronger than the deficient Conibear 120 trap (Proulx et al. 1989b) and, therefore, could cause greater damage to a trapper's hand. However, there are ways to safely handle this trap (Proulx et al. 1989a). Animal rightists take advantage of this resistance of wildlife biologists and trappers to use humane traps; they preach to the public that the fur industry does not want to change (Anonymous 1990).

Proulx and Barrett (1989a) recommended to phase-out trapping devices for which efficient and more humane alternatives exist. However, for years, there was a lack of leadership in incorporating technological advances at the manufacture level (Proulx and Barrett 1988, Barrett and Proulx 1989). Such delays could be interpreted as a refusal of the fur industry to change. Fortunately, some humane traps are now being manufactured and distributed to trappers (Proulx 1990). The full impact of this achievement, however, will be lost if not accompanied by a sound public education program.

Despite Canada's standards for killing taps, there are still sub-standard traps being used in the field much as they were before alternative trapping systems became available. As humane trapping technology now exists, the national standards should be enforced to avoid criticism by animal rightists (Proulx and Barrett 1989a). There still is a pressing need for international trap standards. Unfortunately, the development of these standards is the result of informal meetings and exchanges which are characterized by a "cooperative antagonism" (Dodd 1988). Without effective leadership and coordination, writing of these standards will be unnecessarily delayed; such circumstances only benefit the animal rightists. Any new standards should incorporate the data on humane traps that were developed through sound scientific procedures such as the sequential testing used by the Vegreville research team. In the past, preliminary research programs have led to premature favorable judgments of trapping devices based on inadequate data (Proulx and Barrett 1989a). On a short-term basis, such studies may have given the impression that something significant was being done to improve humaneness in trapping. On a long-term basis, however, they may delude the public's understanding regarding the need for credible scientific work.

We believe that animal rightists are wrong to continue to claim that there is no humane trap. Many of these traps were developed, and are now manufactured and used by trappers.

Conclusion

Fur trapping is part of wildlife management programs aimed at ensuring the future of viable furbearer populations and habitats, and human multi-use activities. Animal rights groups are wrong to categorize all wild furbearer trapping as cruel and unnecessary. However, these groups are here to stay and so is trapping. If the fur industry had to disappear, more trappers would be hired as wildlife/pest control officers and traps would still be needed. Wildlife managers must ensure that the most humane trapping devices available are used and they must continue to meet the animal rightists' challenge. It is well known that wildlife managers will never be able to change the philosophy of animal rightists. However, they can inform and convince the public, other scientists and the politicians about the necessity of their programs and the soundness of their management tools.

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Trapping—An Animal Rights Issue or a Legitimate Wildlife Management Technique—The Move to International Standards

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It is important to set an objective framework for discussion of any issue as controversial as trapping. I intend to do so without formulating any value judgement, but instead by attempting to provide the rationales for the positions taken by wildlife management agencies and by animal rightist organizations. In the process of so doing the strengths and weaknesses of both positions should be illustrated.

At the outset, it must be recognized that fur trapping is, has been, and as long as it continues will be, basically a commercial enterprise. A means not to provide meat (although subsistence cultures and some nonnative trappers do use the meat of species like beaver, muskrat and raccoon), not to provide recreational opportunity (although some agencies and trappers will profess this to be the case) but rather to procure and then sell the pelts of the animals that have commercial value (Todd and Boggess 1987). This basic fact becomes evident when, as in the last two years, fur prices drop substantially and participation rates follow suit. Furbearing animals are also trapped to protect the interests of other commercial activities such as agriculture, forestry and recreational hunting as well as to remove animals causing problems with human habitation (beaver and raccoon in urban areas are modern examples for the latter).

Wildlife management agencies that have condemned commercial activity for other wildlife species readily embrace the concept when it comes to furbearers. Why the dichotomy? Why is it acceptable to utilize one renewable resource for the purpose of economic gain and not another? Selling of game meat is surely a parallel activity to the selling of fur. Yet the procurer of a hunting license does not have the same rights as someone who has purchased a trapping license.

What arguments have been used to defend trapping as a wildlife management technique? A useful place to start is with some North American litigation associated with proposed trapping bans (Gentile 1987). In Ohio, a 1977 proposal to ban trapping with leghold traps or the use of any trapping device in a manner that would cause continued prolonged suffering was defeated primarily as a result of a massive media campaign by the Wildlife Legislative Fund of America (Goodrich 1979). Perhaps the most contentious claim made was that trapping reduced the prevalence of disease potentially transmissible to humans, in particular, rabies. This claim contradicted a 1973 report by the National Research Council Subcommittee on Rabies that stated that persistent trapping or poisoning campaigns to control rabies were ineffectual and should be abandoned. Furthermore, major vectors such as bats and skunks are either not trapped, or few are trapped commercially. Voigt and Tinline (1982) examined the relationship between fur trapping and rabies in red fox in southern Ontario and concluded that normal levels of commercial trapping have little effect on the course of rabies outbreaks. Even intensive trapping can have mixed results (*see* Lewis 1975, MacDonald and Voight 1985, Pybus 1988). Another argument made is that, without trapping, wildlife populations would outstrip their support base and thus trapping helps sustain healthy populations. This appears to be a half-truth. Species like beaver and muskrat can, and do, build up numbers which result in ''eat-outs'' and facilitate intra-specific disease transfer, e.g., Tyzzer's disease in muskrats (Karstad et al. 1971, Wobeser et al. 1978) and tularemia in beaver (*see* Stenlund 1953, Labzoffsky and Sprent 1942). But predators generally self-regulate their populations relative to the available prey base, e.g., wolf (*see* Fuller and Keith 1980, Keith 1983). Often predator trapping is used to increase populations of prey species such as ungulates or waterfowl to improve human hunting opportunity, or reduce high predator pressure caused by man's activities (*see* Balser et al. 1968, Beasom 1974, Duebbert and Lokemoen 1980, Theberge and Gauthier 1985).

It turns out that the best supportive arguments for trapping animals are economic but over a broad spectrum. Holland and Duncan (1988) point out that the fur value was a relatively small component of the economic impact of animal trapping in the state of Oregon. The major items were values estimated for agricultural, forestry and recreational damages or damage prevention if trapping did not take place. The dollar value of confirmed livestock losses to predators in the United States in 1988 was more than $2.5 million but these losses confirmed by Animal Damage Control (USDA) personnel probably represent but a small fraction of total U.S. livestock losses to wildlife (Anonymous 1990).

If trapping is a management tool to control populations of furbearers, why do most jurisdictions regulate solely on the basis of open and closed seasons, not limit the number of trappers licensed or employ many intensive forms of population management? Quotas often are established for species on registered traplines and, in some jurisdictions, usually only beaver censuses for population estimates are made, although track counts and other indirect population indices plus biological monitoring by carcass examination may be conducted also (*see* Anderson 1987, DiStefano 1987, Hamilton and Fox 1987, Linscombe 1987, Melchior et al. 1987, Novak 1987, Slough et al. 1987). Henderson (1985) concluded that no long-term studies have been completed to assess the effects of trapping on furbearer populations with the requisite control areas for experimental observation. Intuitively we know that release of a population from a major mortality factor such as trapping can result in an increase in animal numbers but this effect may be short-term until a new dynamic equilibrium is reached within the context of the remaining environmental factors affecting the species (*see* Todd 1981). Also, we have historical evidence with many furbearers that over trapping can eliminate populations and there has been recent concern that lynx populations were threatened in many areas of North America because very high pelt prices had resulted in intense trapping pressure on that species. Yet, except for a few studies such as those for muskrat (c.f. Bishop et al. 1979, Parker and Maxwell, 1984, Proulx and Gilbert 1983, 1984) there are few population data and virtually no cause/effect information based on commercial trapping. Simulation studies for predator control efforts such as those by Connolly and Longhurst (1975) suggest that population control is an elusive long term goal and that effective damage control as recommended by a number of commissions (Leopold et al. 1964, Cain et al. 1972) is best achieved by targeting the problem individuals. Overall, there is only limited justification for the claim that trapping is necessary to control populations of furbearers.

Instead of using arbitrary quotas or length of seasons which are unsophisticated regulatory tools without having sound population data available, the best management approach for the land areas of North America outside the registered trapline system may be similar to the Ontario Private Lands Fur Management Program (Buckland 1987). Most jurisdictions do not control trapper numbers or take (except for those species with quotas and then it is only take per trapper not total take that is regulated). While this can be effective when a single trapper controls a registered trapline and thus will manage for long term stable productivity of furbearers, it otherwise is ineffectual for regulating actual take. Ontario's approach to this problem was threefold. It created Private Lands Fur Management Areas (PLFMA), it controlled trapper numbers and set harvest quotas and it established trapping councils. The PLFMA's varied in size dependent primarily on the ability of the area to support furbearers. The number of trappers per PLFMA was intended to be small (≥5 to ≤45) but in practice numbers have been considerably higher ranging from 20 to almost 100 trappers. Each trapper must obtain permission to trap a minimum acreage. The intent is to restrict a trapper to trapping within a single PLFMA. Establishment and effectiveness of trapping councils requires voluntary input of the trappers in each PLFMA. This group should become the management body, recommending quotas and other regulatory concerns. This system could be a model for all areas not managed by registered traplines. By limiting the number of participants per unit area, trappers obtain a vested interest in managing, rather than competing for, the resource.

In essence, furbearers are renewable resources, as are deer, elk, waterfowl and pheasant. Consumptive use of these resources is justifiable as long as the management programs are responsive to biological realities, especially the population dynamics of the species involved, and the harvest is conducted so that respect is given to landowners and to individual members of the species. This latter point is the legitimate basis of support for humane harvesting techniques. Harvest technologies and the sets used must have humane potential and the harvester must be adequately trained to realize that potential. Herein lies the only common ground between most users and nonusers of wildlife resources.

Animal rightists take a moral position that the interests of animals should equal the interests of humans and inappropriate uses should be stopped (c.f. Singer 1975, 1985). This contrasts with the position of animal welfarists who may not condone animal use but will accept it if it is done humanely (c.f. Schmidt 1990). Animal rightists have used the mass media effectively but their advertisements and the claims behind them are filled with the same type of simple unsubstantiated rhetoric previously used to justify trapping. Examples include allegations that (1) the leghold trap is universally inhumane, cruel beyond belief and nonselective and, (2) trapping results in species becoming threatened or endangered. While many authors have challenged animal rightists (e.g., Herscovici 1985, Howard 1990), the dogma used by the animal rightists remains the basis of their success. It matters not that leghold traps exist that can and do capture furbearers with no or minimal injury, that killing traps exist that kill quickly and therefore humanely, that traps can be made selective by the set used and such mechanical attributes as trigger configuration, size, triggering sensitivity, etc. The facts are irrelevant especially when they contradict the media hype.

Nilsson (1980) states "that unless action is taken by conservationists and humane organizations many more species will become endangered and cruelty to wildlife will continue unabated.'' Dyson (1985) considers ''trapping (to be) inherently cruel.'' Make no mistake about the end objective sought by animal rightists—it is to abolish trapping (cf. Fox 1976, Singer 1985, Regan and Singer 1989). If trapping is an important wildlife management tool, and it appears that valid economic arguments can be mounted for damage control and scientifically based fur harvests, then the devices used must be defensible with respect to animal welfare. In fact, even more than the lack of sound scientifically based population data for many trapped species, the traps are the most vulnerable component of the management system. For although there are methods and devices that are humane, the evidence overwhelmingly indicates that the majority of traps marketed do not in fact kill or hold wildlife humanely (Anon 1981). This situation is the real ''Achilles' heel'' of pro-trapping advocates.

Efforts have been underway in North America and elsewhere for many decades to find humane trapping devices and for about 15 years to establish humane standards for traps. The earlier efforts have been summarized elsewhere (e.g., Manthorpe 1979, Barrett et al. 1988). I want to concentrate on the international events relating to the effort to establish humane trap standards.

The Canadian research effort under the Federal Provincial Committee for Humane Trapping focused primarily on killing devices (Anonymous 1981) and generated enough information to allow the development of a Canadian Standard for Animal Traps, Humane, Mechanically Powered, Trigger Activated in 1979 with the final standard being approved in 1984 by the Standards Council of Canada (Anonymous 1984). While much of the initial trap research effort was generated as a result of political pressure in North America, international animal rightist forces captialized on the success of the anti-sealing campaign to shift their focus to anti-trapping. The earlier efforts of animal welfare groups provided abundant propaganda material in the form of films such as ''They Take So Long to Die'' and ''Canada's Shame'' with graphic footage showing some of the possible injuries to target species in killing and leg holding traps as well as to non-target animals like birds and domestic pets. Because the European Economic Community (EEC) had proven to be fertile ground for economic sanctions against seal pelts and products, a similar effort was mounted to ban the import of pelts or products of animals captured with the ''cruel and inhumane'' leghold trap. A broader international initiative occurred at the CITES meeting in Botswana in 1983 when a resolution was introduced by Gambia to prohibit trade in products from animals ''taken by cruel methods including the steel jawed leghold trap.'' Although the resolution was not adopted because it was outside the purview of CITES (''ultra viries''), Canada used the forum to introduce the concept of pursuing international standards for humane traps. The Canadians viewed the international threat to commercial trapping as likely to continue and sought to address the animal welfare concerns by pursuing the development of international humane trap standards with the existing Canadian killing trap standard potentially allowing quick implementation for killing devices. In order to form a technical committee of the International Organization for Standardization (ISO), Canada had to find at least four other countries willing to support such action as participants. Canada would function as secretariat. ISO/TC191 came into existence in 1986 to establish standards for Humane Animal (mammal) Traps. Six countries including Argentina, Australia, Finland, Sweden, West Germany and the United States joined Canada as participants. There are currently 10 other countries with observer status. The United States participation is under the aegis of the American National Standards Institute (ANSI). The U.S. Technical Advisory Group (TAG) was formed in 1986 to provide a forum for discussion and development of proposed standards. Membership on the U.S. TAG has comprised veterinarians, state and federal wildlife managers, state and national trappers' association members, conservationists, industry representatives, and academics. Washington State University serves the role of coordinator for the TAG.

The Secretariat for ISO/TC191 is provided through the Standards Council of Canada and Environment Canada. The first meeting was held in Quebec City in March 1987 with four countries (Canada, U.S., West Germany and Sweden) represented. Three Working Groups (WG's) were established at that meeting to be responsible for drafting components of the international standard with WG1 responsible for definitions, WG2 for killing type traps and WG3 for restraining devices. While Canada took leadership roles in WG1 and WG2, the United States had that responsibility for WG3. The U.S. TAG has met twice a year since 1986 defining terminology, reviewing existing data, recommending research needs, responding to draft material from WG1 and WG2, and in turn drafting criteria for humane restraining traps. The Canadian National Standard for Killing Type Traps was submitted to TC191 and given to WG2 for consideration and possible adoption. WG2 has almost completed it revision of the document to serve as part of a draft international standard.

All three Working Groups met together in Edmonton, Canada in November 1988 in conjunction with the International Symposium on Trapping Wild Furbearers (Anonymous 1988). Technical experts from Finland, the Netherlands, New Zealand, Sweden and the United Kingdom joined those from Canada and the United States to discuss progress on the standards development process. In conjunction with this effort is an ambitious research program funded through the Fur Institute of Canada by Environment Canada and the International Fur Trade Federation. A multi-million dollar investment has been made in research and technology development related to humane trapping systems. Important work on restraining devices has been conducted in Alberta and at the University of Minnesota and at Utah State University in association with USDA animal damage control personnel. Some new work is being funded on mechanical characteristics for standards testing of restraining devices by Furbearers Unlimited. Sweden has a trap testing program underway through the National Veterinary Institute to certify humane killing and restraining traps. Extensive field testing of traps has been conducted in the U.S., Canada, Australia and New Zealand.

The Canadian Secretariat of TC191 has certain deadlines to meet in the ISO process. Draft standards will be submitted for review by participant and observer countries in 1991 or 1992. The target deadline for completion of the work of TC191 is 1994.

As mentioned earlier, the European Economic Community has been a recent additional incentive for the ISO process. The European Parliament has, through its committee structure, reviewed a proposed European Commission regulation on "the importation of certain furs." The External Relations, Environment and Economic and Social Committees held hearings in 1989 and 1990 with intensive lobbying by both animal rightists (anti-trapping) groups and North American government and industry (pro-trapping) interests. The U.S. position has been that the Trade Representatives' Office should be involved with the issue as many believe that the process could result in adoption of an unwarranted trade barrier.

Specifically, the opinion formulated by the European Parliament in 1990 in its response to the Commission's proposal and the various committee amendments would require fur pelts, furs and other by-products be banned from import unless it could be demonstrated that the animals had not been captured with leghold traps and the originating countries adhered to international standards for humane traps. The ban would become effective in 1995 with the possibility of a one-year extension if satisfactory progress toward international standards and other requirements had been shown. The ban would apply to 14 furbearing species, including marten (sable), fisher, beaver, otter and raccoon.

The parliamentary opinion is considered by the Commission which then drafts a final proposal for submission to the Council of Ministers. The only significant change would be amending the requirement for banning leghold traps and implementing international standards to an either/or situation. This makes sense as the international standards, if adopted, would cover restraining devices including the leghold trap. The European Parliament would require harmonizing legislation from the member countries so that they adhered to the same restrictions concerning leg hold traps being imposed on countries exporting to the EEC. A major animal rights effort is likely to be mounted in 1991 by the International Fund for Animal Welfare to flood the European Parliament with letters supporting the wording endorsed by that body in 1990.

Another international effort at eliminating the steel-jaw leghold trap was undertaken by the Animal Welfare Institute and Defenders of Wildlife from the United States. This time the International Union for the Conservation of Nature (IUCN) was targeted. A draft motion was submitted to the 17th General Assembly of IUCN at its meeting in Costa Rica in 1988. If adopted, the motion would have read that the IUCN strongly urged that:

1. steel-jaw leghold traps be eliminated throughout the world;
2. when it is necessary to capture animals, methods which permit release without injury or non-target individuals be substituted; and
3. any capture device be regularly visited to release any unwanted animal within the same day that the capture device was set to prevent stress to the animal, whether or not of an endangered or threatened species, and to ensure that no impairment of health and well-being which might result in premature death of a threatened or endangered animal be caused.

The motion was tabled for further study by the Secretariat but it created a real dilemma for IUCN. IUCN adheres to the principles of the World Conservation Strategy which basically allows the sustainable use of wild animals. While the strategy allows the support of conservation areas where exploitation would not occur, it does not contain language that could justify elimination of trapping as a form of exploitation of wildlife. However, even if trapping and in particular the steel-jaw leghold trap met the sustainability criterion, there was considerable opposition to use of exploitation devices which cause suffering and are perceived to be universally inhumane. Furthermore, another complicating factor was that adoption of the motion had the potential to disrupt a traditional way of life of indigenous peoples.

The Director General of IUCN, Dr. Martin Holdgate, wrestled with the draft motion to develop an IUCN policy statement related to "the harvesting of furbearing animals and the use of particular capture methods" that would placate both the pro- and anti-trapping interests, yet adhere to existing IUCN policy. Unhappy with the balanced resolution crafted by the Director General, the Defenders of Wildlife resubmitted their earlier motion for the 18th General Assembly which added the constraint that "where the transition for use of steel-jaw leghold traps to alternative capture methods would cause a temporary hardship to indigenous peoples, special consideration shall be given to providing them financial assistance or creating an exchange of leghold traps for alternative less cruel traps" (part of Resolution 18/41).

The resolution submitted by the IUCN Council (Resolution 18/40) at the Perth, Australia meeting in 1990, upheld the acceptability of sustainable harvest of wild animal species, asserted that the capture methods "be as specific, immediate and humane as practicable" welcomed the ISO initiative to develop international humane trap standards and proposed that where a traditional capture method could be replaced by one more humane, assistance should be given "to achieve a substitution."

The motion finally adopted was a resolution relating to "Methods for capturing and/or killing of wild terrestrial animals." It formally linked the concepts of conservation and animal welfare with the statement "Whereas conservation implies a sense of caring and concern for the welfare of wild animals that are killed or captured" and upheld the concept that sustainable use of wild animals for human benefit was in keeping with the World Conservation Strategy. The resolution embraced the development of international standards, scientifically based for humane traps and established a goal to eliminate, as soon as practicable, the use of inhumane traps throughout the world.

Thus we have two bodies, EEC and IUCN that have recognized the ISO TC/191 initiative as the only feasible solution to the current controversy engendered by the animal rightist efforts to stop trapping, and in particular eliminate the steel-jaw leghold trap as its symbol. Should international humane trap standards be adopted it is scientifically possible that the steel-jaw leghold trap might meet the restraining device standard for some species in certain trapping situations. The benefit to wildlife management agencies of having such standards in place would be the opportunity to have trappers release uninjured from restraining devices particular sex and age categories of the target species that may need protection (e.g. breeding age females). This would allow the manager to be more efficient relative to resource sustainability. Coupled with a selectivity requirement in the standards, the concern associated with the capture of nontarget animals, especially threatened and endangered species, also would be substantially reduced.

Ultimately, the future of trapping as a wildlife management tool hinges on the success of the ISO TC/191 process and that success is far from assured at this point in time. Not only is consensus necessary within the various TAGs and WGs, but it must also be reached among the participating countries. Should international standards be adopted it will still require legislation at federal, state and provincial levels before fur exported from North American jurisdictions would be accepted in Europe assuming the proposed fur ban regulation is passed by EEC and before Canada and the United States could be considered adherents to IUCN policy. The stakes are high and the outcome by no means assured. Trappers, wildlife managers, conservationists and all sectors of the fur industry must recognize that collectively they need to support the ISO process if an international fur market is to continue and commercial fur trapping is to be available as a wildlife management tool.

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Wildlife Management or Animal Rights—Lessons from the Harp Seal

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Wildlife management in the 1990s will be greatly affected by the animal rights movement. Protests against licensed hunting, control of predators and the wearing of fur coats have increased in frequency in recent years. In order for wildlife managers to work effectively in an arena increasingly polarized by the emotional issues of wildlife "management" versus "rights" for animals, it will be necessary to strike a balance between management needs and public opinion. Towards that end, it is useful to examine the harp seal controversy. Few animal welfare campaigns have captured and dominated the attention of the American public more completely than the annual harvest of the harp seal in the Canadian Atlantic Provinces. The issues involved are a complex and confusing mixture of biology, politics and socio-economics.

In the early 1960s, little or no Canadian government regulation of the seal hunt existed. Since the advent of the anti-sealing campaign in 1964, however, the harp seal hunt has become one of the most highly regulated and scrutinized harvests ever conducted. Operating under increased scrutiny, the Canadian Department of Fisheries and Oceans worked hard to balance their best understanding of the resource with the socio-economic needs of the sealers and the claims of seal hunt opponents. These three constituencies, the anti-hunt activists, the sealers and the agencies charged with wildlife management, have been battling for over 25 years with public opinion and the future of the seals hanging in the balance. The activists chose the media as their powerful weapon, the agency chose biology, and the sealers chose tradition and self-determination.

While the activists were successful in making the harp seal a household name in the United States and western Europe, this visibility should not be confused with public knowledge of the intricacies surrounding the conflict. Public opinion has been determined by the images of the pups juxtaposed against the hunters, rather than a careful consideration of wildlife management policy. What follows is an examination of the harp seal conflict from its commencement in 1964 to its diminishment in the late 1980s.

Biology of the Seal

Phoca greonlandica's common name comes from the characteristic horseshoe or Irish harp-shaped black band running across the back and along the flanks. The harp seal's feeding range covers much of the North Atlantic while its breeding range is restricted to three well defined locations: the White Sea of U.S.S.R., Jan Mayen Island northeast of Iceland, and the eastern coastline of Canada. The Canadian population can be further divided into two distinct breeding populations: the "Gulf" population which breeds in the Gulf of St. Lawrence in the vicinity of the Magdalen

Islands, and the "Front" population found along the southern coastline of Labrador from Belle Isle to Hamilton Inlet (Figure 1).

Following a summer spent widely distributed in the North Atlantic, the adults move southward in the early fall toward the breeding grounds. Given satisfactory ice conditions, the females begin to whelp in the Gulf of St. Lawrence in early March followed by the Front population a few weeks later. It is estimated that 90 percent of all sexually mature females are in whelp at the beginning of the breeding season (FAO 1979). The single pup (twins are rare) grows rapidly on its mother's milk and will be weaned after only eight to twelve days (Ridgeway 1981). From birth to weaning, the neonates are referred to as "whitecoats."

After weaning, the pups begin their first molt and begin to move toward the water's edge. During this time they are known as "ragged-jackets." On completion of the molt, the seals have a gray pelage with darker patches. These "beaters," as they

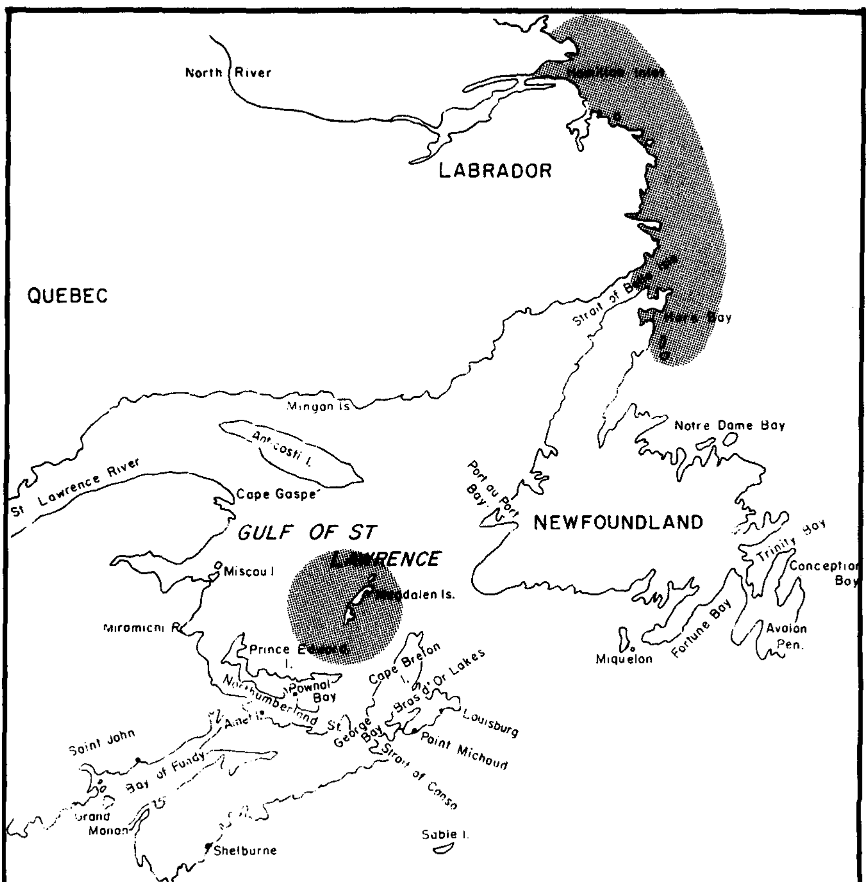

Figure 1. Breeding distribution of the harp seal in Atlantic Canada (breeding ranges are highly variable due to nature and movements of whelping ice).

are known in sealing jargon, feed primarily on euphasids and amphipods while remaining apart from the adult population which is intent on breeding. Following the next molt, the one year old seals will become "bedlamers."

As the adult population is massed together only once a year, both whelping and breeding are accomplished at the breeding site. Shortly after the pups are weaned, the males arrive and mating takes place. The gestation period of 7.5 months is preceded by an 11-week delayed implantation allowing for a total elapsed time of 11.5 months. There is also evidence that the female can retain the fetus until suitable ice is available (Ridgeway 1981). As the pack ice recedes with the coming of summer, the seals drift northward. Adults feed on a range of benthic and pelagic finfish, and crustaceans, with principal target species including the capelin (*Mallotus villosus*) and northern cod (*Gadus morhua*) (FAO 1979). As the summer wanes, the adults begin their return south while the juveniles remain behind.

Sealing

Sealing has been part of the socio-economic background of Atlantic Canada since the time of the earliest settlements. On the rocky and desolate shores, described by some as the "Land that God gave Cain," inhabitants have looked to the sea for their livelihoods. Historically, sealing was just one form of subsistence hunting in the outports that also included the collection of seabird eggs, shooting of seabirds and fishing. It was not until the 19th century that sealing became an industry capable of producing thousands of pelts for export (Greene 1933). As technological methods improved, the size of the harvest increased. Sealing in Atlantic Canada traditionally involved both a landsmen and vessel supported hunt. Seals were taken by one of several methods which included gaffing, clubbing, shooting and long-lining. After World War I, the use of spotting planes to locate the seal herds, together with the move from "wooden walls" to the use of steel-hulled ships, made sealing much more efficient than in years past (Table 1).

The modern technique of the whitecoat hunt on the Labrador Front entails locating seal herds by aircraft or helicopter with the parent vessel moving into position as close as pack ice allows. Teams of sealers disembark and "coppy" across the ice in search of seals. When the female/pup pairs are found, the whiteocats are clubbed. The whitecoat is bled to death and the "sculp" (pelt and blubber) is taken along with the front flippers. The sculps are dragged to a central spot and marked by a flag with the ship's name on it. A proficient sealer can harvest some 100–125 seals per day during a season which lasts three to four weeks.

Once airlifted or loaded on board ship, the pelts are sorted and the flipper removed. The flippers are an important part of the sealer's income as they are sold separately from the sculp with the proceeds going directly to the crew. Profit from the sculp is divided in a manner similar to corporate fishing boats with the vessel owners receiving the largest share (50–75 percent), followed by the captain, first mate and so on down the line. Between 1960 and 1981, the average price for pelts increased from \$3 to \$40 each (highest prices paid for quality bedlamer pelts). Prior to 1983, the pelts were largely exported to Europe for fur and leather goods. Ironically, for those who oppose the hunt, the white fur of the newborn harp seal was most preferred because it could be dyed for those wishing to mask the true origin of the fur. The

Table 1. Chronology of harp sealing (Templeman 1966, International Council for the Exploration of the Sea [ICES] 1982)

1794	Offshore hunt begins.
1825–1860	Harvest commonly exceeded 500,000 seals annually.
1860	292 Wooden-walls (schooners) employed 14,121 men.
1863–1894	Harvest averaged 341,000 annually.
1881	27 Steamships employed 5,815 men.
1895–1911	Harvest averaged 249,000 seals annually.
1912	23 Steamships employed 4,179 men.
1914	252 men lost their lives in single sealing season.
1912–1940	Harvest averaged 159,000 annually.
1920	9 Steamships employed 1,583 men.
1921	Spotting planes first used.
1949–1961	Harvest averaged 310,000 annually.
1962	Helicopters introduced to hunt.
1962–1970	Harvest declined to average of 287,000 annually.
1969	59 vessels employed 817 men + 2,952 landsmen.
1971	Quota management introduced.
1971	89 vessels employed 1,568 men + 3,070 landsmen.
1971–1981	Harvest averaged 172,000 including 133,000 whitecoats.
1983	European Economic Community ban on seal pup products.

blubber was used in lotions, soaps, lubricants and margarine while the flipper meat was considered a favorite seasonal fare.

In considering the history of sealing in Newfoundland and the Magdalen Islands, it is important to recognize sealing's integral role in the socio-economics of the outports. Newfoundland and the majority of other Canadian Maritime provinces remain impoverished areas, heavily dependent on the sea for their livelihood. Populations are widely distributed along the coast, with everything from education to entertainment the sole responsibility of the outport. Historically, sealing ships were among the few enterprises that paid cash for a day's labor. While income from sealing varied greatly depending on the season, method of sealing and pelt prices, the income came at the end of a long winter when provisions were low and cash scarce. A sealer's income in the early 1980s ranged from $4,000–5,000 for a crew member aboard one of the large Canadian sealing vessels, to a range of $1,400–2,700 for small boat operations, and $400–700 for landsmen (Canada 1983, Canadian Wildlife Federation [CWF] 1983). While this amount may seem small by American standards, sealing could account for one-fifth to one-third of a Newfoundlander's total annual income.

In addition to presenting an opportunity to earn cash after a long winter, sealing was part of the social ritual of manhood. Much as a youth in Gloucester, Massachusetts looked to "cut his teeth" aboard a fishing schooner out on the "banks," so too did the outports view sealing as a prestigious undertaking. Sealing had the "manly" attributes of hard work, male companionship and danger.[1]

[1]The hunt of 1914 illustrates the dangers of sealing. The *Southern Cross* was lost in a storm with all hands and another wooden wall, *Newfoundland*, lost a sealing crew on the ice. A total of 252 men lost their lives (Brown 1972).

Table 2. Harp seal harvest, Atlantic Canada, for selected years 1970–1990 (includes landsmen, longliners and large vessels for Canada and Norway)

Year	Quota	Reported harvest	Average pelt value
1970		257,495	$ 8.82
1971	245,000	230,966	
1972	150,000	129,883	$10.48
1973	"	123,832	
1974	"	147,635	$12.30
1975	"	174,363	
1976	127,000	165,002	$15.95
1977	160,000	155,143	
1978	170,000	160,460	
1979	"	159,922	
1980	168,200	168,594	$27.00–$40.00
1981	168.200	189,301	
1982	175,000	161,843	
1983	"	57,889	
1984	"	30,900	
1985	"	17,723	
1986	186,000	26,989	$16.15
1987	"	45,282	
1988	"	78,277	
1989	"	67,860	$17.00
1990	"	52,757	$12.00

Today, the combined pressures of lower pelt prices and public outrage are seen as a threat to the heritage and culture of the sealers. Outsiders attacked a two-century-old tradition that spanned generations of commercial sealing and subsistence hunters. Seemingly lost in the outside world's debate over the hunt's moral, ethical and wildlife management qualifications was an adequate consideration of the cultural importance of sealing to numerous Canadian outports with such telling names as ''Seldom Come.'' Such considerations have played a major role in policy debates for the Pribilof fur seal hunt, northern spotted owl conservation and other wildlife issues in the United States.

Conflict and Confrontation

From its beginnings in the 1700s through 1963, commercial sealing was essentially unregulated by outside forces except those of the marketplace. Following World War II, technological advances and renewed effort led to increased demand and exploitation of the seal herds. As early as 1950, there were calls for control of the harvest and Sergeant and Fisher (1960) estimated that the western North Atlantic harp seal population declined by one-half during the period 1950–1960. Unlike the decades before, however, the 1960s would mark the beginning of an anti-sealing campaign that brought Canadian sealing to the attention of the world, and closed the markets of western Europe to seal pup products.

While there had been early film documentaries of the harp seal hunt, the release in 1964 of a film by Artek Studios of Montreal showing a seal pup being stunned by a kick, slit open and then skinned alive by a person seeming to enjoy the cruelty caused an international uproar. Shortly afterwards, an article entitled "Murder Island" was published in more than 300 newspapers around the world. Canada began to receive the waves of protest, both public and diplomatic, that continued into the 1980s. While the authenticity of the film has been debated, it captured the attention of conservationists and the public with its graphic portrayal of the seal hunt.[2] Organizations, such as the Canadian Audubon Society, and several scientists raised concerns that too many harp seals were being killed and that the harvest level was not sustainable (Royal Commission 1986). In 1966, Brian Davies, of the New Brunswick SPCA, and a team of observers followed the hunters on the ice. A veterinarian with the team found that 95 percent of the seals examined in the vicinity of the observers had fractured skulls (i.e., likely to have been unconscious at time of skinning) while skulls examined one-half mile away showed only 50 percent had been crushed (Davies 1970). This 50 percent figure would be a major focus of reform for protesters and government officials alike.

As the anti-hunt movement began to take shape, different objectives began to emerge. For some critics, the goal was to "clean-up" the seal hunt and regulate it in such a manner as to make the hunt as humane as possible while still maintaining a harvest. For others, however, the goal was closing down the seal hunt altogether. These objectives often became confused and misunderstood. For the protesters, vivid imagery and gripping prose became the staples of their protest as they worked to gain increased media coverage and international attention. Who could resist the image of "little balls of white fluff with huge dark eyes that cry great tears as the hunters approach" (Davies 1970). On the other hand, there was suspicion on the part of the Newfoundland people that these protesters had come to change their way of life.

> *They'd not be on to hurting we, them Greenpeacers, if whitecoats ugly little fellers. Oh no, wonnerful little money in ugly* (McCloskey 1979).

This attitude pervaded the entire conflict, and while the various protest organizations repeatedly denied any windfall from the harp seal issue, there can be no doubt that this issue brought them untold wealth in the form of media coverage, membership and overall exposure. To the sealers, the protesters represented just one thing: outsiders without any understanding of their life-style who had every intent of "saving seals" regardless of its impact on the sealers and their communities.

Though the debate over the harp seal hunt has been largely waged on the grounds of cruelty, animal rights and other moral issues in the 1960s, there was also concern among fisheries experts over how much exploitation the population could endure. There are numerous examples of hunting pressures on marine mammals causing extinction or population extirpation. The sea mink and Stellar's sea cow are two examples of extinct mammals. The Guadalupe fur seal, twice thought to be extinct, exists today in a single remnant population.

With thousands of harp seals on the ice each season, little notice was paid to overall numbers or recruitment rates. The first official Seal Protection Regulations

[2]According to McCloskey (1990), the man depicted in the Artek film skinning a live seal signed an affidavit that he had been paid to do it for the camera while the two other "sealers" shown actually were members of the film crew. As McCloskey noted "such retractions after the fact do not, however, affect the hammer blow of original impressions."

were introduced in 1964. These regulations restricted the method of killing, shortened the season of the hunt, required all sealers to possess a license and set a quota for the Gulf herd. In 1970, the use of aircraft for spotting was banned. The Front harvest remained without a quota largely because much of the whelping ice lay outside Canada's three mile territorial limit. In 1971, a Joint Commission on Sealing (Canada and Norway) was formed and a quota of 200,000 seals agreed upon for both countries on the Labrador Front. In 1972, this quota was reduced to 120,000 on the Front and 30,000 for Canadian landsmen. In the Gulf, large sealing vessels (over 65 feet) were banned while landsmen and hunters who operated from small boats were allowed to continue their hunt. For the first time, a distinction was made between the large sealing vessels (often foreign and corporately owned) and the smaller boat operators and landsmen (Coish 1979). In addition to regulations, efforts were directed at determining population sizes and trends. The International Council for the Exploration of the Sea (ICES) estimated pup production in the late 1960s to have been 320,000–420,000 with an adult (one year and older) population of 1.2–1.6 million. For the period 1977–1980, ICES estimated pup production to have been 380,000–500,000 with an adult population of 1.5–2.0 million (ICES 1982).

Changing the Rules

The early years of the conflict had a marked effect on the seal hunt—supervision of the harvest improved and greater competence on the part of the sealer was required. After observing the 1968 hunt, the New Brunswick SPCA noted improvement in the killing methods with the estimated number of seal pups potentially skinned alive reduced to approximately 3.3 percent (Davies 1970). There continued to be room for improvement, however, as supervision remained thinly distributed and the potential for improper killing increased as the sealers grew tired and cold.

The first decade of conflict over the harp seal can be listed as successful for all parties. A hunt, once conducted with little regard to sustainability and animal welfare, was now largely a regulated fishery operated in as humane a manner as possible. If the goals of the protest were to improve conditions of the hunt, this conflict would have faded into obscurity. In fact, several of the original protesters including the Ontario Humane Society declared their mission a success (McCloskey 1990).

The goals of the remaining protesters, however, had changed and the 1976 hunt marked a resurgence of protest. While past protesters, such as International Fund for Animal Welfare (IFAW), were present, newcomers like Greenpeace also entered the fray.[3] As Chantraine (1980) notes in his book, *The Living Ice*, whether from the great European furriers or from their adversaries, a great deal of money changed hands as a result of the harp seal. While IFAW had campaigned against the hunt's cruelty, Greenpeace, fresh from defending whales from Russian harpoons, contended that the harp seal was a species in danger of extinction. Developing new avenues of publicity and media attention, Greenpeace announced they would throw themselves between the sealers' clubs and the whitecoats to save the pups and spray their white pelts with a green dye to render them valueless until seals molted. The Canadian government promptly responded by declaring the discoloration of seal pelts illegal.

[3]IFAW was formed by Brian Davies in 1969, after New Brunswick SPCA found its "Save the Seal" campaign too draining on their other activities.

The protesters went to great lengths to vilify the hunt, spending undisclosed thousands of dollars on print and direct mail campaigns. The purpose of these campaigns was to build outrage, and the direct mail and ads featured pictures of bleeding seals with sensational claims of intentional cruelty. Several ads were considered too graphic to run in the United States but did appear in European newspapers. These ad campaigns built revulsion against the killing of baby seals. Absent was any attempt to put the hunt into a larger perspective of seal populations, outport culture and gains made in regulating the hunt.

In 1977, there were more protesters, photographers, press and publicity surrounding this hunt than ever before. Brigitte Bardot arrived in eastern Canada to add her voice to the seal campaign. Her participation started a wave of movie and television personalities who gave harp seal preservation their personal endorsement. In addition, Franz Weber (a wealthy Swiss industrialist) offered Canada 1 million francs (approximately $400,000) to buy the lives of 170,000 seals. Weber also offered to build a synthetic fur factory in eastern Canada to employ the sealers put out of work (Coish 1979).

The sealers, caught in the middle of this media blitz, generally went about their business to the extent possible. At times this was made difficult by Greenpeace activists laying down in front of the sealing ships and environmental activist Paul Watson dumping seal pelts into the water.[4] The saying on the ice among the "swilers" (sealers) was to hit the seal three times—one time for the seal, one time for the fisheries officer, and one time for Greenpeace. Tempers became predictably short and Brian Davies was met in the Magdalen Islands by an angry group that may have resorted to violence had the reinforced police garrison not interceded.[5] While individual incidents of violence may have occurred, the overall response of the sealers was to organize themselves. S.O.S. meant "Save Our Seals" to the abolitionists, but it meant "Save Our Swilers" to the sealers. The Canadian government also vowed their support of the sealers with the House of Commons declaring the "right of Canadians to hunt seals off Canada's east coast." A major reason for Ottawa's show of solidarity with the sealers was the passage in March 1977 of resolutions by the U.S. House of Representatives and U.S. Senate expressing the "concern of Congress that the cruel practice of killing newborn harp seals in Canadian waters may cause the extinction of that species" (U.S. Congress 1977). In presenting its case to the House of Representatives, the Committee on International Affairs noted that the killing of newborn seals "can be likened to other such animals species as the Asian tiger, the African rhinoceros, and various species of whales." The resolution further stated that the Canadian government had "increased its quota to 170,000 or 90 percent of the newborn seal pup population." Apparently Congress relied on American protest groups rather than Canadian scientists for their information, while references to the tiger and rhino suggest that Congress may have considered the harp seal an endangered species. The Canadian government, deeply resenting the United States censure, supported continuation of the hunt with even greater resolve.

[4]Paul Watson gained notoriety as the skipper of the *Sea Shepherd*, which rammed a pirate whaling ship off the coast of Portugal.

[5]IFAW would not be so lucky in 1984 when a similar angry crowd destroyed its helicopter in response to the seal hunt being called off (*New York Times* 1984).

Fuel was added to the anti-sealing campaign during the landsmen hunt of 1981. Because of abnormal ice conditions, ice with whelping seals drifted to the coastline of Price Edward Island. Suddenly a normally scarce resource became available to the local communities. While inexperienced residents poked, stabbed and maimed the seals, the protesters took careful notes and documented the fiasco on film. Finally the Canadian government stepped in and halted the hunt, but not before a great deal of damage had been done, both to the seal resource in terms of unnecessary cruelty and to the "professionalism" of the hunt. In 1981, the Canadian government also initiated a harder line against the protesters. Representatives from the Animal Protection Institute and other organizations observing the Prince Edward Island hunt had their film seized and several were arrested (Feltz 1981). The Canadian government, having improved the regulations governing the harp seal hunt, now took a stance against what they perceived was clearly an attempt to end the hunt all together.

The sealers fought back with their own advertising campaign. They even formed their own protest group, "Codpeace," and had their own traveling theater, the Mummers Troupe, who put on the production "They Club Seals, Don't They?" throughout Canada. The pro-sealing efforts were at least partly effective as a Gallup poll conducted in May 1978 showed 51 percent of the Canadians sampled were in favor of the hunt compared with 29.6 percent in January 1977 (Coish 1979).

But improved Gallup polls were not reflective of international public opinion which continued to build in favor of the seals. The protest was carried to western Europe where an appeal was brought before the Common Market to ban the importation of harp seal pelts. The breadth of the anti-sealing campaign in Europe was impressive. Among the activities of IFAW was the presentation of a 3-million-signature petition to the president of the European Parliament and the purchase of full-page advertisements in 15 European newspapers. An estimated 5 million postcards and letters were received by ministers of European Parliament (Royal Commission 1986). In 1984, the protesters effectively pitted western Canada fisherman against Atlantic Canada sealers, and the ministers of Trade and External Affairs against Fisheries, by calling for an international boycott of Canadian fish. "Don't buy any tin or package of fish bearing the words "product of Canada . . . Help stop the world's most unspeakable wildlife massacre once and for all . . . Save the Seals, No to Canadian Fish" (IFAW 1984). Now the sealers not only felt pressure from the European and American public, but from fellow Canadians as the boycott began to impact fish exports. These efforts were viewed by Canadian Government as a "campaign of vilification" and they responded with the threat of fisheries sanctions against any European country that sided with the anti-sealing forces. With the passage of the 200-mile exclusive economic zone in 1977, Canada's refusal to grant nations such as West Germany permits to fish inside Canadian waters was a strong economic threat, but it was not enough.

On October 1, 1983, a European Communities Directive prohibited the import of the skins, raw or processed, of harp seal pups (whitecoats) and hooded seal pups (bluebacks).[6] It was a mere formality since the market for whitecoats had already collapsed. Sealing as an industry and socio-economic force in Atlantic Canada changed

[6]In a maneuver that would make a true parliamentarian proud, the EEC vote to ban import of products derived from young seals was attached to a "morality provision" written to curb the international flow of pornography.

dramatically with the collapse. Although seals continued to be killed in 1984 and 1985, a market for the pelts was essentially non-existent. In 1984, the Royal Commission on Sealing was established to examine the sealing question, including management policies, ethical issues and public concern. The Commission published its report in 1986, and many of its recommendations were adopted by the Department of Fisheries and Oceans in 1987 (Royal Commission 1986). The new seal policy included a ban on the hunting of whitecoats and bluebacks, no large vessel offshore seal hunt, greater regulation of sealing methods, close monitoring of the seal populations, and authorization of funding to develop new opportunities for sealers and sealing communities affected by the collapse of the sealing industry (Canada 1987).

As a result of these new policies, the harp seal hunt has been largely removed from the public eye. Activists have been replaced on the ice by tourists. IFAW and several other organizations conduct nature tours to the Magdalen Islands and Nova Scotia to view the whitecoats first hand.[7] In 1989, the European Community indefinitely extended its ban on the importation of whitecoat pelts. It is significant to note, however, that while the ban was extended indefinitely, it was not widened to include other seal pelts.

Seals continue to be hunted in the Canadian Atlantic and Arctic. The hunt is conducted in accordance with the Royal Commission's guidelines: current levels of harvest do not appear to endanger the species (in fact, fishing interests are increasing their call for seal culls); harvesting methods are humane; and the hunt is carried out for socio-economic benefits without appreciable waste in areas where alternative economic opportunities are scarce. The strident protests have ended, but lasting scars remain. The seal pelt market has not recovered from its collapse in 1983–1984 and sealers face continued economic hardship as public opinion has failed to change. The protesters enjoy lasting success in that realm. The images, so successful in the capturing a distant public, of whitecoat pups bleeding on the ice while cruel hunters stand by, have proven to be the most lasting images of the entire controversy.

Lessons for the Future

From the streets of Aspen, Colorado to the woodlands of Mason Neck National Wildlife Refuge in suburban Virginia, animal rights protests are impacting wildlife management. The harp seal conflict marked the beginning of the modern animal rights protest where the powers of the electronic media in combination with direct mail and the international financial community were combined into a force that overpowered concerns for Canadian sovereignty and regional self-determination. The harp seal issue offers numerous lessons to be remembered in striking a balance between wildlife management and animal rights.

1. *Don't confuse polls for pals.* While Gallup polls reveal a notable lack of public support for the goals and actions of animal rights activists, wildlife managers can take no refuge behind such numbers (Wildlife Management Institute 1991). A 1978 Gallup poll indicated majority support for a harp seal hunt but that is of little solace to the Newfoundland sealers now. The animal rights movement can only grow in strength and breadth as the American population becomes

[7]A recent study by Kovacs and Innes (1990) found that seal behavior has been significantly affected by the activities of the tourists on the whelping ice.

increasingly separated from the natural environment. The most noteworthy polls are those that demonstrate declining numbers of hunters, trappers and fisherman. A growing segment of the population has been described as active in "watchable wildlife" activities (a.k.a., non-consumptive users), but they cannot yet be counted as a constituent.

2. *Avoid a "them versus us" mentality*. Another disturbing trend is the rise of organizations formed to combat the animal rights movement. While there can be little doubt that the animal rights movement threatens to end hunting and redefine wildlife management, professional wildlife managers may not be able to afford the battle. First, like "Codpeace" and the "'Mummer Troupe," they may be outgunned and may lose a face-to-face battle. Further, they risk the alienation of potential constitutents. Wildlife managers love wildlife every bit as much as animal rights supporters; the difference lies in their appreciation for animal populations and habitats rather than individual animals. Just when conservationists got used to fighting the traditional villains like dam builders and mall developers, along came animal preservationists. A perfect case in point is found in the Central Valley of California where efforts by animals rights advocates to close the waterfowl season threatens to remove 60 percent of the available wetlands habitat maintained by private hunting clubs. The response of Cleveland Amory, perhaps the best-known animal rights spokesman, is "I don't want the killers to provide the habitat" (Dolan 1990).
3. *Educate the Fuzzy-wuzzies*. Richard Conniff (1990) tackled the animal rights issue head-on in the pages of *Audubon* and found that the "animal rights movement has elevated ignorance about the natural world almost to the level of philosophical principle." Surveys have shown that the public's level of knowledge concerning wildlife issues is extremely low (Kellert and Berry 1980, Royal Commission 1986). Faced with this finding and the growth of an animal rights movement founded on emotion rather than knowledge or first-hand experience, the obvious response is education. This educational campaign must include strong visual images and emotional appeals that are the wildlife management equivalent of seal pups, and the educational effort must be backed by a budget worthy of a sustained campaign, the very ingredients that made the harp seal protest a success for the animal rights activists.
4. *Don't underestimate the power of emotion*. It has been noted that "no sacrifice is too great for someone else to make as long as it is free to you" (Anderson 1989). In the case of the harp seal hunt, not only were the media images overwhelming, but the effected human parties (i.e., the Canadian Atlantic outports) were far removed from the centers of debate in Washington, D.C. and Europe. The campaign mounted so effectively against a two-century-old hunting tradition had nothing to do with logic or fact, but rather with emotion and conscience. Who could resist "little balls of fluff with huge dark eyes that cry great tears as the hunters approach" (Davies 1970)? Who could condone the death of defenseless baby seals to provide nothing more than frivolous curios for the rich? No amount of scientific evidence can stand up against these kinds of images and the perceptions they build.
5. *Use or be abused by the media*. The power of the Artek Studios film in 1964 demonstrates both the power and dangers of the electronic media. While the film was largely discredited, its impact on the sealing controversy was lasting.

Wildlife managers must recognize that declaimers after the fact are of little consequence in shaping public opinion. A single image of an animal being slain, whether on the ice floes of the North Atlantic or at the gates of Yellowstone National Park, will capture the visual media's need for a ''sound bite'' much more completely than the often lame-sounding explanations offered by a wildlife professional after the fact (e.g., ''the management action conducted was consistent with the scientific principles of resource management''). Solutions lie in making the media work for, rather than against, wildlife management, and in making the professional wildlifer media savvy.

6. *Develop an offense, not a defense.* Former Congressman Tip O'Neil (D-Massachusetts) always cautioned that ''all politics is local.'' The harp seal controversy supports this claim. When the U.S. Congress censured Canada in 1977 for the seal hunt, they were responding to their constituents (the letter writers who voted them into office) just as the European Parliament was also responding to its constituents. What elected official wouldn't take notice of an issue about which he or she received over 300,000 pieces of mail?
7. *Beware the ''CM Factor.''* If we were to develop a nomenclature that classified animals by the emotional response they evoked from humans, harp seals, especially whitecoats, would rate a ''10'' (on a scale of 1–10). Assuming management was based on this same nomenclature, all harvest of these animals would be strictly prohibited. Whales, tigers, pandas and other ''charismatic megafauna'' would also come to share this exalted rank. In contrast, the cockroach and rat would rate a ''0'' and could expect no protection. Since such a ranking is indefensible, wildlife managers must structure a response that recognizes an animal's ''CM Factor'' (charismatic megafauna) without losing sight of the scientific principles that mandate a control hunt or other actions based on demonstrated human need. Just as foresters have come to recognize that there is no such thing as a ''good-looking'' clearcut when it comes to the general public's perception of timber operations, the same is true with harvesting a live animal by club or gun. While reports by august scientific organizations might find that proper use of a club constitutes an ''effective humane means of producing unconsciousness and death,'' do not expect such a finding to change the public's opinion or perception.
8. *Be cool.* Wildlife professionals who vent their anger in dealing with animal rights protesters will be ineffective in advancing their side of a wildlife issue. Brian Peckford, Newfoundland Minister of Mines and Energy, responded during the harp seal protests that ''clubbing seals is no different than picking oranges in Florida.'' Protesters quickly made use of the quote to demonstrate the callousness of the sealers (HSUS 1979). Duda (1990) recommends making the opponent look like an extremist by maintaining composure regardless of what is said or done. While easier said than done, it is essential that wildlife managers show themselves as professionals and worthy representatives of wildlife.
9. *If not you, then who?* As the harp seal issue clearly illustrates, sound wildlife management will not prevail on the strength of science alone. It needs advocates that can persuade and educate with eloquence and conviction. As Jack Ward Thomas (1986) concluded, ''it is useless 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 the agents of change in how natural resources are treated, considered and used."

Conclusion

There is little question that the harp seal hunt was badly in need of regulation in 1964. For their role in improving the conduct of the hunt, animal rights activists should be justly proud of their efforts. Credit must also go to the Canadian government and the sealers themselves for this improvement. Efforts to end the hunt, while largely successful, pitted emotion against wildlife management against human right of self-determination. Emotion won and the outside world returned to its own business. The residents of Atlantic Canada were left with winter unemployment rates that reach 90 percent, a spring sealing industry that watched pelt prices fall from a high of $40 for a prime pelt in 1981 to $12.00 in 1990, and a sour taste in their mouths. The outports are not alone, as the fallout has been felt throughout the Arctic as Inuit and other traditional aboriginal cultures have been impacted. In examining the harp seal controversy to glean lessons for the future, a wildlife manager far from the ice is likely to lose sight of the human element that played such a large part in this issue.

> *I pray the death you harbor in your heart sinks into your groin to render you impotent* (letter to Canadian government [McCloskey 1979]).

> *I'd got enough work sculpin' 'um dead widdout a live animal jumpin' under me knife beside*" (response to claims of skinning a live seal [McCloskey 1979]).

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A Proactive Approach to Meeting the Animal Rights Challenge

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Introduction

As we've seen during today's session, the animal rights movement is impacting wildlife management programs across North America. Fish and wildlife management agencies are increasingly being challenged over traditional uses of animals such as hunting, trapping and fishing, and are concerned about potential change in public support for their programs. Many wildlife professionals in the past took the view that the animal rights movement consisted of radicals that would eventually go away and could therefore be ignored. However, the movement is growing, is well-funded, and presents an appealing argument to many segments of the public. The four largest animal rights organizations in the United States have over 1.4 million members with combined annual budgets of $25 million. These organizations, and many others, have sophisticated state and national networks and connections to worldwide animal rights organizations, primarily located in Europe. Articles on animal rights are appearing in more and more popular magazines, reaching more of the public than ever before. In the past two years, articles have appeared in Esquire, Glamour, Science, Newsweek, and U.S. News and World Report, to name just a few.

A distinction must be made between "animal welfare" and "animal rights." Animal welfare focuses on ensuring humane treatment of animals. Animal rights is the belief that animals have rights similar to humans and that any use of animals by humans (food, sport, pets, entertainment) is morally wrong. It's important to remember that animal rights as a philosophy does not mean simply "anti-hunting," but is a broader philosophy opposing most and, in some cases, all human use of animals. While many animal rights organizations have targeted trapping and hunting as their major issues, some of these organizations are, in fact, opposed to human manipulation of the environment: including wildlife management. Because the philosophy of animal rights opposes not only hunting and trapping, but also the underlying assumptions upon which the profession of wildlife management is based (Decker 1987), we can equate the animal rights movement with an "anti-wildlife management" movement.

The Proactive Strategies for Fish and Wildlife Management Project

The Animal Welfare Committee of the International Association of Fish and Wildlife Agencies (IAFWA) established the Proactive Strategies for Fish and Wildlife Management Project (Proactive Strategies) in 1989 in direct response to the anti-wildlife management challenge. The Animal Welfare Committee is approaching the project in three ways. First, the importance of applying solid planning to this problem was recognized. The Organization of Wildlife Planners, an IAFWA affiliate, was asked to help develop a plan to guide the project and to work with the Animal Welfare Committee on plan implementation.

Second, there is a need for wildlife professionals to look at what we practice as a profession and to address wildlife management policies that may be, at best, inappropriate, and, at worst, not in the true interest of the wildlife resource. Proactive Strategies calls this "putting our house in order" or dispelling any myths that may adhere to our profession.

Last, Proactive Strategies believes that the answer to meeting the anti-wildlife management challenge already exists within the ranks of our profession. Proactive Strategies supports the view that it is not necessary, nor desirable, to hire outside experts to solve our problems. If "the answer" does not largely originate from within the wildlife management community, there is slim chance that it will be accepted by wildlife professionals.

A definition of the term "proactive" is useful in discussing the Proactive Strategies project's overall philosophy. "Proactive" means much more than just "the opposite of reactive." Dudley Lynch and Paul L. Kordis (1988), in *Strategy of the dolphin: Scoring a win in a chaotic world*, offer the following definition: "proactive" means "shifting the focus away from fixing what's wrong to envisioning what's possible." In other words, to look into the future and anticipate what is possible, rather than reacting to issues that are forced upon us. In the Proactive Strategies project we are trying to change perceptions about wildlife management before these perceptions are changed by someone else—in this case, by those not supportive of wildlife management.

Proactive Strategies' main focus is on developing strategies that state and provincial fish and wildlife agencies can use to proactively meet the anti-wildlife management challenge. Collectively, and individually, the states and provinces are experiencing a wave of anti-wildlife management activities. Hunter harassment, newspaper editorials, lawsuits and public demonstrations, to name a few examples, are impacting the way fish and wildlife agencies do business. Agencies have been reacting after the fact in almost all cases. What is needed is an action plan to guide state and provincial fish and wildlife agencies individually and collectively on how to manage changing public sentiments effectively. Proactive Strategies is developing that action plan.

The project's mission statement is straightforward: "To provide effective strategies with which the IAFWA and its governmental members (states and provinces), through coordinated implementation, can maintain and increase support for professional fish and wildlife management and long-term conservation programs." This sounds easy, but is extremely complex when you look at the underpinnings of what Proactive Strategies is trying to accomplish.

The primary goal of the project is to mitigate the anti-wildlife management movement. To accomplish this, two major objectives have been identified. First, to develop an array of communication methods for use by state and provincial fish and wildlife agencies and others to maintain and increase acceptance and support for professional fish and wildlife management programs. The second objective is to develop the necessary legal and logistic coordination for state fish and wildlife agencies to meet the challenge posed by the anti-wildlife management movement.

Under these objectives, 20 specific action items have been identified (Table 1). The list includes items from understanding the animal rights movement to communicating wildlife management values to the public to building the capability to seek common ground with all stakeholders, including anti-wildlife management activists.

Table 1. Proactive Strategies for Fish and Wildlife Management Project's major objectives. Specific action items are listed as subobjectives under each major objective.

Objective A. Develop the necessary legal and logistic coordination for state and provincial fish and wildlife agencies to meet the challenge posed by the anti-wildlife management movement.

1. Seek to understand the anti-wildlife management movement;
2. Identify anti-wildlife management activities;
3. Determine credibility of anti-wildlife management interests;
4. Determine legitimacy of anti-wildlife management interests;
5. Understand public view and attitude; and
6. Build coalitions supporting animal use.

Objective B. Develop an array of communication methods for use by state and provincial fish and wildlife agencies and others to maintain and increase acceptance and support for professional fish and wildlife management programs.

1. Share information on the anti-wildlife management movement;
2. Communicate the anti-wildlife management movement methodology;
3. Communicate with media—news and entertainment;
4. Increase wildlife management credibility; encourage fish and wildlife resource agencies to use practices that best conserve fish and wildlife resources;
5. Increase visibility of effective wildlife management;
6. Educate youth, educators, and those new to wildlife management profession;
7. Encourage state and provincial agencies to make an adequate investment in their information and education divisions (I&E);
8. Ensure adequate programmatic public explanation;
9. Clarify and communicate wildlife management values;
10. Change perception that wildlife agencies are dominated by hunting;
11. Seek public support necessary to implement programs under attack by anti-wildlife management activists; protect research tools used in management of fish and wildlife;
12. Counter emotional anti-wildlife management issues; deal with the value difference inherent in the anti-wildlife management movement;
13. Show public that wildlife management policies are environmentally sound;
14. Seek areas of common ground with all constituents.

This last action item brings up an important issue. The Proactive Strategies project is not a crusade to go forth and do battle with an enemy to be vanquished. When wildlife managers first become aware of this challenge, they tend to want to spend large sums of money and huge amounts of effort on a quick ''killing blow'' on the anti-wildlife management proponents. However fish and wildlife agencies, as public entities, represent all constituencies, even those that oppose wildlife management.

Putting Our House in Order

We all recognize that some constituent groups will not be satisfied until hunting and trapping are eliminated. It is unlikely that we can change these constituents' values and make them supportive of hunting and trapping. But there are additional publics who have reasoned concerns about our activities. A large part of the Proactive Strategies project is looking at wildlife management policies and actions to see if wildlife management as it is currently practiced is (1) in the best interest of the resource and (2) in keeping with current societal demands. Taking a hard look at ourselves may mean some uncomfortable introspection, but introspection is vital to ensuring that the wildlife profession is, in fact, continuing to serve the resource through proper management. As professionals we must remain cognizant of how well wildlife management practices are keeping step with the times. Proactive Strategies is not proposing that fish and wildlife agencies totally accede wildlife management decisions to societal demands. Societal values, however, must be understood and appreciated. Wildlife professionals must be aware of a variety of views about wildlife as they formulate wildlife management policies and programs. This amounts to balancing scientifically sound wildlife management with societal needs to produce the best possible solution for the resource. It is up to the wildlife profession to ensure that the public has adequate information and a balanced perspective upon which to base its view of wildlife management.

Preliminary Results

Proactive Strategies is presently engaged in workshops, studies and data-gathering activities that will provide the ''meat on the bones'' of the project plan. Expected completion date of the project is 1993, with interim products available along the way. All told, there are currently 65 distinct strategies that Proactive Strategies will try to implement; with 10 already under way. We would like to mention some specific projects that we're working on now.

Through a survey of all state and provincial agencies administered in December 1990, we are currently looking at the impacts of the anti-wildlife management movement on state and provincial hunting programs. While the survey is still being analyzed, some general trends can be seen in the survey responses: of the 58 survey respondents, 32 have experienced hunting protests since September 1989, most commonly regarding big game hunts; fully 69 percent of the agencies responding anticipate anti-hunting protests in the future; 68 hunter harassment incidents have occurred in 25 states since September 1989; and of the 58 states and provinces that responded, 80 percent have not had to abandon or modify their hunting management programs due to anti-wildlife management activities. Further analysis of the survey will provide more detailed information on the extent to which the anti-wildlife management movement is impacting fish and wildlife agencies.

Future Plans

The Proactive Strategies Project is organizing a series of regional workshops beginning in March 1991. The workshops will involve getting state and provincial fish and wildlife agency personnel and regional representatives of animal welfare and animal rights organizations together to discuss their perspectives on issues related to wildlife management. Two more surveys, which will be administered in February and April 1991, will look at impacts of the anti-wildlife management movement on trapping programs, and on how fish and wildlife agencies communicate with the public. Project personnel will produce a bimonthly newsletter for state and provincial wildlife agencies to keep them up-to-date on anti-wildlife management issues, and on how other states and provinces are meeting the challenge. The final product of Proactive Strategies will be an issue management handbook for fish and wildlife agencies to use proactively, and also to use when faced with a controversial situation.

We are involved in a process of learning to manage changing public sentiment toward wildlife and the environment. Managing change does *not* mean that the wildlife profession is abandoning traditional supporters of fish and wildlife management. Rather, fish and wildlife agencies must evolve and work at building new layers of public support for wildlife management programs and conservation efforts. Proactive Strategies' goal is to provide the strategies to help state and provincial agencies maintain and increase this necessary public support for sound, sustainable fish and wildlife management.

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Urban Deer Management Programs: A Facilitated Approach

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Proposals to hunt deer in urban areas have produced heated debate over deer population levels, the impact of deer on vegetation, deer health and deer/vehicle accidents (Kuser and Applegate 1985). Often, groups appointed to evaluate options for managing deer populations have continued to recommend hunting as the best course of action (Cobb 1982). In several situations, efforts to implement hunting programs have been met with litigation and disruptive activities by anti-hunting groups (Cook 1974, Lampton 1982).

Conflicts over hunting involve deeply rooted value and belief systems (Kellert 1978, Peyton 1984, Schmidt 1989). Technological information about hunting as a management technique has been considered adequate but has not provided the basis for compromise due to the disparate belief systems of the stakeholders (Peyton 1984). In recent years professional facilitation has shown promise as a mechanism for developing consensus recommendations on difficult issues (Ohio Environmental Council and New Hampshire Citizens' Task Force on Acid Rain 1986). This concept is based on respecting the legitimacy of conflicting views and honoring the dignity, intelligence and sincerity of antagonists.

In this paper, we describe a facilitated approach used to develop an urban deer management program in Minnesota. This paper is taken largely from the Final Report and Recommendations of the Minnesota Valley Deer Management Task Force (Minnesota Valley Deer Management Task Force 1990). Our intent is to chronicle the steps taken to reach the final recommendations and to provide the background for evaluating our results in the setting in which this program occurred.

Background

Deer damage to native and planted vegetation and deer/vehicle collisions have been increasing since the late 1970s in the cities of Burnsville, Bloomington, Eagan and Mendota Heights, Minnesota. These cities border the Minnesota Valley National Wildlife Refuge and Ft. Snelling State Park which are public lands covering 8.4 square miles of the lower Minnesota River Valley. The area also includes lands owned by the cities and by private citizens. Deer population reduction efforts were slowed by firearms discharge bans in each city and by opposition to killing deer.

From 1984 through 1988, the four cities annually granted the Department of Natural Resources (DNR) authorization to hold public deer hunts and to conduct sharpshooting using conservation law enforcement officers in the Minnesota Valley National Wildlife Refuge and Ft. Snelling State Park. Conflicts over the hunting programs occurred each year and in 1989, the Burnsville city council requested the DNR convene a task force to resolve the issues. The Council indicated they would not approve further hunts until the task force had issued recommendations on deer management for the lower Minnesota River Valley. After approval by the Director of Fish and Wildlife, the DNR agreed to form the Deer Management Task Force (DMTF) to facilitate a deer management agreement among all factions.

DMTF Features

The DMTF objectives, as proposed by the DNR and approved by the cities, were to: (1) identify problems associated with deer populations in the lower Minnesota River Valley; (2) review past and proposed deer management by the resource agencies; (3) review existing and potential deer population control methods and recommend methods to be used; (4) recommend desirable deer population densities; and (5) recommend practical methods for implementing a comprehensive deer management program.

The DMTF was composed of at least one representative from each of the federal, state and country resource agencies, one appointee form each city, one representative from three pro- and three anti-hunting organizations, and one representative from a non-hunting conservation group (Table 1). DMTF members were selected to represent a diversity of views on the issues but not to reflect the will of the public on hunting or wildlife management. This feature of the DMTF was intended to reduce the polarization inherent in processes involving majority and minority groups. The DNR supplied a facilitator to conduct the meetings and to write, with the DMTF's approval, meeting summaries and the final decisions made by the group.

Table 1. Agencies and organizations represented on the Deer Management Task Force, 1989–90.

Type of group	Participant
Municipalities	Bloomington
	Burnsville
	Eagan
	Mendota Heights
County resource agency	Dakota Parks
	Hennepin Parks
State resource agency	MN Dept. of Natural Resources
	Division of Parks and Recreation
	Section of Wildlife
Federal resource agency	US Fish and Wildlife Service
	MN Valley National Wildlife Refuge
Animal rights and welfare	Friends of Animals and Their Environment
	Minnesota Network for Animal Concerns
	Minnesota Valley Humane Society
Hunting, shooting and fishing sports	Izaak Walton League, Minnesota Chapter
	Minnesota Deer Hunters Association
	Minnesota State Archery Association
Conservation	Minnesota River Valley Audubon Club

The DMTF considered itself a fact-finding group and thus, agreed to make all decisions by consensus or unanimous consent. When the group could not agree on an issue, opposing views were given equal time in the meetings and equal space in the final report. Equal representation of alternative views was considered to be a safeguard against renewing basic value conflicts and the undermining of DMTF decisions by the minority viewholders. In fact, the DMTF never voted on issues regardless of significance.

The DMTF agreed to close their meetings to attorneys and the media, and to allow observers and specialists to participate by invitation only. All participants pledged to act in good faith during discussions and to maintain confidentiality about statements made or positions taken during DMTF meetings. Members agreed to meet at least monthly and to issue a final report and recommendations by 30 June 1990. Inquiries from the public and the media about the DMTF process or progress were to be handled by the facilitator. Press releases or articles written by DMTF members had to be reviewed and approved by the group.

The DMTF defined the area of impact of their recommendations as the lands within the boundaries of the four cities, although the group recognized the implications their work might have in similar communities. Finally, all members of the DMTF committed themselves to the framework and groundrules described above by signing a ratification agreement.

Results

The DMTF held 18 meetings and one field trip from April, 1989 through June 1990. In four meetings during April and May 1989, the DMTF developed and sent to the cities deer management recommendations for 1989–90. These recommendations essentially maintained the public hunting and sharpshooting programs used in 1989, allowing time for the DMTF to complete their work.

Discussions about development of long-term deer management programs began in September 1989. During the initial sessions the members listed their concerns about deer populations in the study area which later became the basis for topics discussed by the group. The concerns were: (1) the criteria and authority for setting deer population density objectives; (2) the effectiveness, acceptability and availability of deer population control methods; (3) deer/vehicle collisions; and (4) deer impacts on vegetation. The stages of issue definition, description and discussion preceded an often difficult process of developing recommendation statements that represented a consensus on each concern. The final report and recommendations included an issue statement and a set of recommendations regarding each issue.

Recommendations

Deer Population Densities

Deer population densities, expressed as numbers of deer per square mile, were accepted as the principal indicator of the size of deer populations. The DMTF recognized the expertise of the resource management agencies in setting numerical density goals for units within the study area. The DMTF recommended that agency staff carefully consider the following factors in developing density goals: (1) deer/

vehicle collisions; (2) natural habitat browsing; (3) damage to ornamentals and crops; (3) deer health, particularly reproductive rates; (4) natural population variability; (5) resource agency ecosystem management objectives; (6) consumptive and non-consumptive uses of deer by people; (7) land-use diversity; (8) community tolerance of deer population levels; (9) artificial feeding; (10) human health; and (11) accuracy and variability of deer census data.

Deer Population Management

The DMTF adopted a two-step process for evaluating control methods. First, methods that could possibly achieve population reduction objectives within the study area were identified. Second, those methods that could be effective and would be acceptable and useful as management tools, were evaluated.

The DMTF listed as indirect deer population management methods the use of fences/movement barriers, repellents, habitat manipulation, artificial feeding and no action. Direct methods included fertility control, trap and transfer, trap and kill, hunting, sharpshooting, and reintroduction of predators. Fences/movement barriers and repellents were not considered as potential population control methods but were evaluated for controlling vegetation damage.

The final population control recommendations were described by method and intended use on the study area (Table 2). All methods listed were considered available and potentially effective and acceptable. Consensus was not reached on the use of hunting to control populations and thus, opposing statements of identical length were printed in the final report (Minnesota River Valley Deer Management Task Force 1990:Appendix E).

Although the DMTF could not reach consensus on hunting, ideas developed during the extensive discussions resulted in formulation of an Alternative Deer Control Program (Table 3). This program, although not entirely new as a method for killing deer in controversial situations, represented an alternative that was unanimously supported by the DMTF.

The Alternative Deer Control Program differed from public hunting in that a special selection process was to be used to identify qualified participants. The eligibility qualifications and standards of conduct were more restrictive than are generally required for public hunting. In addition, the Alternative Deer Control Program was solely focused on balancing deer population densities with specific, well-defined criteria.

The Alternative Deer Control Program differed from sharpshooting in that participants were to be selected from among qualified members of the general public. Also, deer removal methods were limited to slug-loaded shotguns as opposed to the rifles used by sharpshooters. finally, shooting by any method not specifically listed in the program description, was not allowed.

Deer/Vehicle Collisions

The DMTF recommended techniques for implementation by local governments for reduction deer/vehicle collisions. These included increased compliance with deer/vehicle collision reporting, identification of areas with high frequencies of deer/vehicle collisions, installation of wildlife warning reflectors at high frequency collision sites, media coverage of hazardous locations and methods for driving defensively during seasons of increased deer movement, improved road shoulder vegetation

Table 2. Deer Management Task Force recommendations regarding use of methods for managing deer populations.

Method	Description	Use
No action	"Let nature take its course"	Not likely effective area-wide or long-term; may be suitable on short-term basis or in certain areas.
Reintroduction of predators	Releasing wolves and coyotes	Not suitable because of insufficient habitat, cost, and public tolerance.
Habitat manipulation	Creating or enhancing habitat	Not suitable; protection of critical deer habitats was encouraged.
Artificial feeding	Food supplements or planted crops	Not effective for controlling populations; may affect deer movements and distribution in limited situations.
Fertility control	Chemical agents for reducing or preventing births	Cannot currently be implemented; agencies should monitor research developments.
Trap and transfer	Live-trapping, transporting and releasing deer	Not cost-effective or suitable area-wide or long-term; may be used in limited circumstances; stressful to deer.
Trap and kill	Live-trapping and killing deer	Used on small land parcels when problems have been documented by the DNR and after appropriate non-lethal methods have been exhausted; must be used humanely and according to regulations set by the DNR.
Sharpshooting	Shooting of deer by approved law enforcement staff	Used where population reduction needs, availability of staff, and public safety concerns are appropriate.
Alternative deer control program	(*see* Table 3)	Used on state and federal lands within the study area.
Hunting	Hunting of deer under state regulations	Unable to reach consensus on this issue.

control at high frequency collision locations, and efforts to discourage citizens from feeding deer near high frequency collision areas. Information on wildlife warning reflectors and agency addresses and telephone contacts were provided in the final report.

Vegetation Damage Control

The DMTF felt current methods, particularly the use of fencing and repellents, to reduce deer to all types of vegetation were excellent and needed to be communicated to the public. Local governments were encouraged to refer people to agency and university staff for information pamphlets, videos and demonstration projects on the most effective damage control methods. Agencies were also to discourage deer feeding by people with vegetation damage.

Table 3. Alternative deer control program proposed by the DMTF for managing deer populations.

Feature	Specifications
Objectives	To reduce and control deer populations to maintain deer health in balance with the ecosystem and to reach tolerable levels of deer impact on vegetation and on deer/vehicle collisions. To NOT provide for a sustained yield of deer. To establish preference for shooting and registering weak, crippled and maimed deer. To provide a safe and effective method for controlling deer populations in as humane a manner as possible.
Participants	Resource managers will determine the number of participants based on densities necessary to conduct a safe, effective deer kill. Participants selected from random drawing from pool of qualified applicants. If under 18 years of age, participants must be accompanied by a qualified, selected adult and have previous deer hunting experience. Participants must complete an orientation course stressing safety, program objectives and rules, ethics and the need to make rapid, humane kills. Members of the DMTF could monitor sessions. Participants must follow rules and applicable laws and regulations. Violators will have their current permit revoked, be ineligible for program participation in future years and prosecuted, if warranted. After the first year, applicants with experience in the program will be given priority. Criteria to increase program safety and efficiency may be recommended at the annual DMTF review meeting.
Logistics	Scheduled to minimize conflicts with public use within the management units. Program may or may not coincide with deer hunting seasons held elsewhere in the state. Participants may be allowed to hunt elsewhere in the state.
Methods	To have resource managers recommend to the DNR Commissioner the number and sex of deer to be killed by each participant each program year. Participants must use shotguns loaded with single slug shells to kill deer. Shooting must be done from elevated stands. All deer killed must be registered at designated locations. Serious, concerted efforts must be made by participants to retrieve wounded deer. Unretrieved deer must be reported to the appropriate agency for further action. Participants may donate deer killed to charitable organizations, social service agencies or deserving individuals.
Duration	This program will be available for use on an experimental basis by affected resource management agencies for three years following its first use.
Evaluation	Results and new recommendations will be discussed annually by the DMTF. A program evaluation by the resource management agencies will be presented to the DMTF at the end of the experimental period.

Artificial Feeding

Artificial feeding of deer was defined by the DMTF as the provision of food to meet all or part of the nutritional requirements of deer. Baiting deer with food to increase their visibility for public interpretive programs was considered a legitimate activity. Independent of the concerns about deer feeding expressed in conjunction with other recommendations (*see above*), the DMTF felt an ordinance prohibiting artificial deer feeding would be unenforceable. Deer feeding on public lands was considered to be in conflict with the management goals of these units, would reduce the available habitat for wildlife, and could provide food only for the early portion of the winter period.

Implementation

The DMTF requested that the DNR obtain a three-year variance from the firearms discharge ordinances when implementation of the Alternative Deer Control Program is recommended. The starting date of the program would be determined by the DNR and Fish and Wildlife Service after discussion with the DMTF.

In April of each year, the DNR was asked to convene the DMTF to review and discuss progress in implementing deer management recommendations. In addition, proposed deer management objectives for the coming year and related matters would be discussed.

All DMTF members ratified the final report and recommendations with their signatures. The ratification also included the pledge to support and encourage others to adopt and implement the recommendations of the DMTF.

Postscript

Reaction of the public to the unanimous agreements reached by the task force was mixed, although implementation of the recommendations is being considered in each of the four cities. Most city councilpersons seemed to feel that the DMTF recommendations were far-sighted and valuable assets to the cities or that the DMTF stymied movement on deer population control by not approving hunting as an ongoing program. Concerns about the continuation of hunting were heightened when the resource agencies agreed that no population reduction would be necessary in 1990–91. Deer population goals of 20 deer per square mile had been set by the agencies and aerial counts in February 1990 resulted in estimated densities of about 20 deer per square mile.

Many members of the Minnesota Bowhunters, Inc. and the Minnesota State Archery Association were angry that bow hunting was not allowed under the provisions of the Alternative Deer Control program. DMTF discussions on bowhunting had focused on the number of deer wounded and not retrieved by bowhunters during hunting seasons. The lack of consensus on bowhunting as an effective, humane method for killing deer resulted only in approval of slug-loaded shotguns as the method for killing deer in the study area.

By early 1991, despite the varied opinions on the DMTF deliberations, members of the DMTF had publically adhered to the agreements. Interestingly, several members of the DMTF have continued to communicate among themselves on a number of issues since the completion of the DMTF report.

Conclusions

While we recognize that managing deer in urban and suburban areas requires the leadership and commitment of professional wildlife staff, our experience in this situation would indicate that citizens in an informal, constructive setting working without limitations, can design innovative, creative and integrated management programs. The fact that this group reached consensus on a number of management issues is proof that there is substantial common ground among the stakeholders in wildlife management on a local level. Although the programs proposed by the DMTF are untested, they have been given high regard as representing the opinions and hard work of local citizens and staff of the cities and agencies involved in the conflicts.

We believe the likelihood of agreement on hunting and wildlife management issues on a larger scale, given the differences in values and beliefs held by the myriad of interest groups, is remote. Without a specific locale whose attributes can be defined and described and for which a "customized" set of management recommendations can be developed, the value conflicts would seem to revert to the types of philosophical arguments that have been heard over and over in many arenas.

We felt an important impetus for the compromises reached by the DMTF was the inherent pressure from the city councils for recommendations to guide the residents of their respective communities. Having an implied responsibility to reach some decisions on a timely basis may have led to more flexibility on the part of DMTF members, especially as the deadline drew near.

Open communication and discussion has also resulted from the deliberations of the DMTF and will continue to produce dialogue where none existed previously. We are optimistic that these exchanges will lead to better and more timely resolution of wildlife management problems in other situations. Perhaps when problems can be limited to a particular area, and stakeholders are identified and given an equal opportunity to participate in the input process, wildlife management programs might best be formulated by community residents and local staff from the resource agencies.

Acknowledgments

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Special Session 8. *Conserving Migratory Wildlife*

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Introductory Comments

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Migratory wildlife, in contrast to resident wildlife, are characterized by complexity. Their existence transcends ecosystems, each with its own habitat characteristics, food resources, predator populations and impacts of human activities. Thus, mortality factors and nutritional status are usually quite different on the seasonally disjunct components of the annual range occupied by migratory populations. Although young may be hatched or born on nesting or calving grounds, reproductive productivity is a product of all of the habitats occupied by the species throughout the year. This complexity in the biology of migratory species is often overlooked in attempts to assess the impacts of proposed industrial development projects on habitat units used by wildlife seasonally. Migratory wildlife species are also characterized by sociality and a high degree of both heritable and learned behavior associated with fidelity to seasonal habitats and use of traditional migration routes and staging areas. The drowning loss of 10,000 caribou in northern Quebec in 1984, as they attempted to cross a river flooded by untimely release of water from a hydroelectric impoundment, is an example of a failed effort to avoid impacting a migratory wildlife species through industrial development. While reflecting on the mysteries of the annual cycle of the large migratory caribou herds of North America, Erik Munsterhjelm, in his book *The Wind and the Caribou* (1935), quoted the Chipewyan adage: "No one knows the ways of the winds and the caribou." This remains today a uniquely appropriate expression of the difficulty in understanding the detailed ecology of this migratory species.

The ecological complexity that characterizes migratory wildlife is paralleled by the complexity involved in their conservation and management. Just as migratory wildlife transcend ecosystem boundaries, they also transcend boundaries of governmental jurisdiction at the regional, national and international levels. Protection of critical habitat units is only effective if matching protection exists for other critical habitats at the opposite extremes of their migratory movements and seasonal existence. Not only are international treaties necessary where migratory wildlife cross national boundaries, but cooperative management agreements within countries between intergovernmental agencies and including private land owners are necessary to assure that the total habitat requirements of migratory species are protected from attrition. The need for such agreements to include indigenous peoples with long traditions of dependence on migratory species has become increasingly apparent as these people achieve greater voice in the management of wildlife within their own lands. We have muddled through the past, often without the participation of all resource users and landowners, but successful conservation and management of migratory wildlife must deal more effectively with their complexity than has been the case in past practice.

Accomplishments of the North American Waterfowl Management Plan

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Introduction

At the 53rd North American Wildlife and Natural Resources Conference in Washington, D.C., in 1988, James H. Patterson and Harvey K. Nelson, then Cochairmen of the North American Waterfowl Management Plan Committee, presented a paper on progress of implementation of the Plan (Patterson and Nelson 1988). Periodic status reports have been presented at other national and regional meetings (Nelson 1988). Other current information is provided through published annual reports, joint venture progress notes and Waterfowl 2000. Much has happened during the past three years. The purpose of this presentation is to outline new program developments, summarize progress and accomplishments to date, and to discuss future actions.

Objectives

The Plan, signed in 1986, provided policy and program guidance and served as a ''blueprint for action.'' The objectives were relatively simple: to secure long-term protection for an additional six million acres of habitat in 34 geographic areas of major concern (the most important breeding, staging and wintering areas); to restore populations of 10 principal species of ducks to 62 million breeders that would produce a fall flight of 100 million birds, a level common to the decade of the 1970s; and cited population objectives for geese and swans. The habitat protection and enhancement alone was estimated to cost \$1.5 billion, of which \$1 billion was designated for Canada, with funding ratios established. The Plan also recognized several other significant points: (1) the minimal priority acreage cited may be increased as project planning progressed, especially through opportunities to apply beneficial land-use practices on private lands; (2) substantial private funding support would be essential to achievement of objectives; (3) the joint venture concept should be adopted to establish partnerships; and (4) although the primary emphasis would be on waterfowl, wetlands and associated habitats, significant benefits would also accrue to a variety of other migratory birds and other wetland wildlife (U.S. Department of Interior and Environment Canada 1986).

Joint Venture Progress

Since the implementation process started in 1987, and through October 1990, seven habitat joint ventures were started in the U.S. and two in Canada as indicated in Figure 1. In December 1990, the first truly international habitat joint venture (Pacific Coast) was launched. The two species joint ventures (black duck and arctic goose) that are now fully organized, are also international in scope. Each joint venture is administered by a management board, with the participating province or state working through a steering committee to carry out projects at the local level. Both organizational levels establish subcommittees for technical and administrative support functions as needed. A coordinator has been assigned to each joint venture, usually by the lead federal agency, who also provide staff support to the management board. Numerous projects continue to be identified within each joint venture as the planning process continues. Individual management plans have been completed for the initial joint ventures, supported by more detailed provincial, state and project plans.

Habitat Objectives and Accomplishments

The joint venture concept is based on the development of partnerships to pool resources that maximize financial, organizational and other in-kind support toward a common set of objectives. Each joint venture has multiple partners, with representation varying. At the governmental level, this includes federal, provincial and state agencies having natural resource management responsibilities, together with county, municipality and other local units of government, and universities. The private sector is represented by national, regional and local conversation organizations, corporate officials and private individuals. Time and space prohibit the listing of all partners for each joint venture, but it is clearly evident that the strong partnership effort demonstrated has been responsible for accomplishments achieved to date.

We have relied on information contained in the Plan, the individual joint venture management plans and current information provided by the joint venture coordinators to summarize habitat objectives and accomplishments.

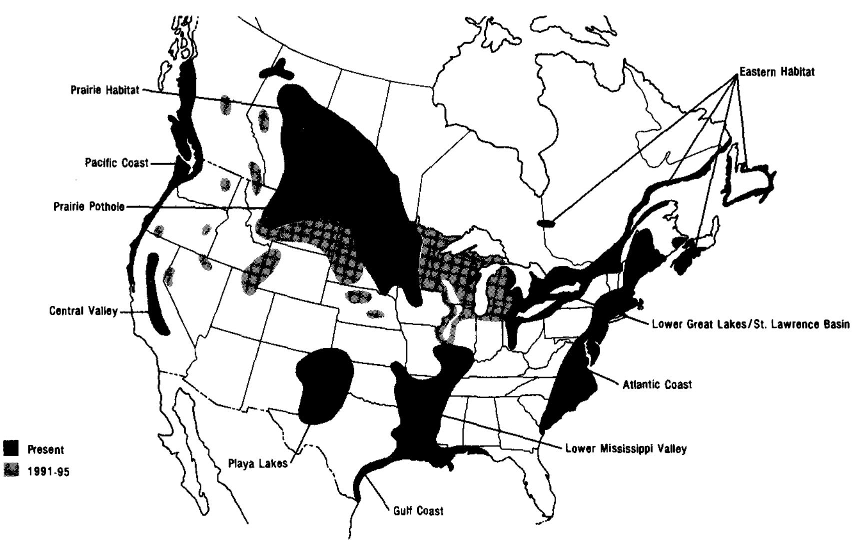

Figure 1. Present and future joint ventures.

A brief status report for each joint venture is presented, based on information available through December 1990.

Canadian Prairie Habitat

The prairie and parkland regions of Manitoba, Saskatchewan, and Alberta contain the continent's most important breeding areas for mallards (*Anas platyrhynchos*), pintails (*Anas acuta*), and blue-winged teal (*Anas discors*), other prairie ducks, and many shore and wading birds. The Plan proposes to protect and enhance 3.6 million acres (1.5 million ha), the largest habitat component of the total program. Fifteen major projects are underway, using a combination of land purchase, conservation easements, wetland and grassland restoration, and application of sound soil and water conservation practices on private lands. About 112,000 acres (45,300 ha) have been treated through a variety of cooperative programs.

To reinforce these habitat initiatives, strong partnerships with federal and provincial agricultural agencies are being formed within in the joint venture for the purpose of helping to shape emerging policies and programs which will reflect the sustainable environment theme. These policy changes are expected to result in long-term positive gains for habitat.

Eastern Habitat

This joint venture includes portions of Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland. These provinces have coastal marshes, interior wetlands and farmland wetlands that provide important breeding, staging and migration habitat for black ducks (*Anas rubripes*), ring-necked ducks (*Aythya collari*), wood ducks (*Aix sponsa*), green-winged teal (*Anas crecca*), several populations of Canada geese (*Branta canadensis*) and sea ducks in certain areas. Many areas are frequented by large numbers of migratory shore birds and other water birds. Some coastal areas are important to breeding eider ducks (*Somateria sp.*) and other marine birds. The objective is to protect, restore or enhance about 617,00 acres (250,000 ha). Priority will be given to protecting remaining coastal marshes subject to industrial and urban development. Special private lands programs will affect the management of an additional 3,952,000 acres (1,600,000 ha) (Eastern Habitat Joint Venture Management Board 1990). To date, about 10,200 acres (4,070 ha) have been acquired, of which 400 acres have been restored, with another 23,280 acres (9,310 ha) of Crown and private land secured by agreement for waterfowl habitat enhancement through beaver pond management.

U.S. Prairie Pothole

The Prairie Regions of eastern Montana, North Dakota, South Dakota, Minnesota and Iowa provide the most important waterfowl breeding habitat in the lower 48 states. The goal of the Prairie Pothole Joint Venture is to involve the public in a broad-scale unified effort to increase waterfowl populations by preserving, restoring, creating and enhancing wildlife habitat. The overriding objective is to maintain an average breeding population of 6.8 million and to provide 13.6 million ducks in the fall flight by the year 2000. Principle strategies include the enhancement of waterfowl habitats currently in public ownership; the perpetual protection, creation, restoration or enhancement of an additional 1.1 million acres (445,300 ha) of wetland ecosystems (wetlands and adjacent upland habitats); and the enhancement of an additional 5 million acres (2.02 million ha) of privately owned wetland ecosystems. To date, 15 specific projects have been identified where resource agency and other interested individuals and organizations are focusing their efforts (i.e., Chase Lake, North Dakota, Lake Thompson, South Dakota, and Hamden Slough Minnesota). In addition, a well-organized private lands effort is underway in all five of the states.

The accomplishments from these efforts are becoming evident. Over 150,000 acres (60,730 ha) of wetlands ecosystems have been placed under long-term protection (fee title acquisition, wetland easements, FmHA easements). In addition, private land activities have benefited over 130,000 acres (52,630 ha) of wetland ecosystems. As the joint venture continues to mature, the private lands initiatives will become one of the principal strategies.

Central Valley

Nearly 95 percent of the original wetlands in this part of California have been lost, primarily through agricultural drainage. During the winter period, about 60 percent of the ducks, geese, swans, and millions of shorebirds and other water birds crowd into the remaining 280,000 acres (110,000 ha) of natural or managed wetlands. The objective is to provide long-term protection to about 80,000 acres (32,400 ha) that are not secured; restore or create 120,000 acres (50,000 ha) of wetlands; enhance 292,000 acres (119,700 ha) of existing wetlands both public and private; and improve habitat conditions on an additional 443,00 acres (179,000 ha) of private agricultural lands through extension, education, conservation agreements and private lands incentive programs. Accomplishments to date include protection of 22,700 acres (9,200 ha) remaining wetlands; restoration of 13,800 acres (5,600 ha) of wetlands and associated uplands; and improved land use practices on 17,000 acres (6,900 ha) on private lands.

Lower Mississippi Valley

This joint venture, including portions of 10 states (Mississippi, Louisiana, Arkansas, Texas, Oklahoma, Tennessee, Kentucky, Missouri, Illinois, Indiana) is designed to provide protection and restoration of forested wetlands along the lower Mississippi River and its tributaries. More than 80 percent of this region has been drained and cleared for agriculture or urban and industrial development. The objective is to secure at least 300,000 acres (120,000 ha) that provide important wintering habitat for mallards, pintail, wood ducks, several populations of Canada geese and large numbers of other waterbirds. In addition to direct purchase and conservation easements, a special effort is being made to coordinate wetland protection and enhancement provisions of the Farm Bill programs, other private lands programs, and other interagency land and water development projects underway in the lower Mississippi Valley. To date, about 102,900 acres (41,700 ha) have been provided direct protection; 81,600 acres (33,000 ha) have been improved through farm program activities; and certain management rights on 57,800 acres (23,400 ha) have been obtained from private corporations.

Gulf Coast

Bordering the Gulf Coast of Mexico from Texas to Alabama, this region provides important wintering habitat for more than one million geese, nearly one quarter of all dabbling ducks, especially mallards and pintails associated with the Mississippi and Central Flyways. It also supports large populations of migrant shorebirds and other waterbirds. The management plan calls for providing long-term protection to 386,000 acres (156,000 ha). Additional acres will be restored or enhanced through Farm Bill programs, other related private lands programs, interagency land and water management agreements, and corporate donations. Implementation is being conducted through six geographic initiative areas. To date, at least 49 projects are underway, with approximately 30 more on the drawing boards. Pilot projects involving "mini refuges" and provision of water on private rice fields during the winter months have proven to be highly successful in improving the distribution of wintering geese, as well as being attractive to dabbling ducks and shorebirds. Various methods to provide additional freshwater for birds wintering in the coastal zone are also being explored. Accomplishments include 49,700 acres (20,100 ha) of wetland protection; 39,125 acres (15,800 ha) of wetland enhancement; and 87,075 acres (35,200 ha) acres of private and corporate lands under management agreements.

Atlantic Coast

Extending from Maine to South Carolina, the areas identified provide important breeding, migration and wintering habitat for most species of waterfowl and a great variety of shorebirds and other waterbirds. Special emphasis is given to the black duck. The principal objective of the Atlantic Coast Joint Venture is to provide long-term protection to 60,000 acres (25,000 ha) of wetland and upland buffer habitats and to improve 166,000 acres (67,200 ha) of wetlands now managed for migratory birds by federal and state agencies. An additional 820,000 acres (332,000 ha) have been identified in the joint venture plan that require further protection and enhancement. Flagship projects include Cape May in New Jersey and the ACE Basin project in South Carolina. Throughout the joint venture, 12 major projects are underway and six more are in the planning stage. About 167,000 acres (67,600 ha) have been protected and 7,710 acres (3,100 ha) enhanced or restored on federal, state and private lands.

Lower Great Lakes—St. Lawrence

The area includes portions of eastern Michigan, Ohio, Pennsylvania, New York and Vermont that border the Great Lakes and the St. Lawrence River Basin. The Plan calls for protection of 10,000 acres (4,000 ha) in the U.S. An additional 551,000 acres (220,000 ha) have been identified in the Plan that require further protection and enhancement. Adjacent areas in Canada are included in their Eastern Habitat Joint Venture. Initial projects have focused on the Saginaw Bay area in Michigan, the Lake Erie marshes in Ohio, the Montezuma areas in New York, Lake Champlain in Vermont, and key black duck breeding areas that require additional protection or enhancement. To date, about 1,645 (666 ha) have been protected and 500 acres (200 ha) improved, involving five projects.

Playa Lakes

Including portions of five states (Texas, New Mexico, Oklahoma, Kansas and Colorado), this joint venture is designed to maintain geologically-unique playa wetland basins. This physiographic region provides important wintering habitat for Canada geese, snow geese (*Anser caerulescens*), pintails, mallards, sandhill cranes (*Grus canadensis*), and a large number of migrating and wintering shorebirds. The area also produces significant numbers of mallards and blue-winged teal. The playa basins and surrounding croplands or grasslands are virtually all in private ownership and many serve as sources of irrigation water for the individual farmers. Some are used as collection ponds for waste-water discharged from cattle feedlot operations, municipal sewage systems or petroleum operations. The objective is to establish at least 40 functional habitat units throughout this area that will include the playas that are determined to be the most important to wintering migratory birds. The intent is to improve the distribution of these wintering populations by accommodating no more than 100,000 ducks and 25,00 geese in each unit. This should also decrease the threat of loss to disease outbreaks, primarily fowl cholera, that occurs periodically. The majority of habitat protection and improvement measures will have to be conducted under conservation easements or other agreements with private land owners. Such efforts are just getting underway.

Pacific Coast

This newly established joint venture is the first truly international cooperative habitat effort between Canada and the U.S. Extending from the northern coast of British Columbia, along the coast of Washington and Oregon to northern California, the objective is to secure about 300,000 acres (120,000 ha) of critical habitat remaining. The primary focus will be on coastal marshes, estuaries and adjacent tributaries that are important to migratory waterfowl and other waterbirds, fish and shellfish that are threatened by further industrial, agricultural and residential development. Another objective is to minimize conflicts between agriculture and wildlife through special land stewardship programs. The prospectus for this joint venture was released in October 1990, and a more detailed management plan is being prepared.

Species Joint Ventures

Black Duck

This species joint venture has a strong research orientation. The principal objective is to develop a better understanding of the breeding ecology, population dynamics, current distribution and other environmental factors influencing the decline in black ducks. Cooperative activities also include the development of new systematic aerial and ground surveys in 1990 in the principal black duck breeding range in eastern Canada and northeastern U.S. More intensive breeding ground banding programs are also being launched to aid in determining annual productivity and survival. Information coming out of these new cooperative studies will also be used in setting future habitat protection and development priorities. The Strategic Management Plan for the Black Duck Joint Venture is scheduled for printing in April 1991.

Arctic Goose

This species joint venture has been in the formative stage for more than two years. The prospectus circulated for review in February 1991 established the scope and primary objectives. Initial investigations will be directed toward 13 populations of geese (white-fronted [*Anser albifrons*], Canada goose, snow [*Chen caerulescens*] and Ross' [*Chen rossii*] geese, and brant [*Branta bernicla*]) that nest primarily north of the boreal forest. The goal is to foster greater research and monitoring of Arctic geese so that improved population management may proceed.

The first field work actually began in 1990, when the Canadian Wildlife Service obtained new funding to commence studies of snow geese and small canada geese in the central arctic area in cooperation with the Northwest Territories. At the meeting of the Arctic Goose Joint Venture Management Board in January 1991, general agreement was reached on how to proceed with preparation of the strategic plan that will specify long-term objectives and commitments by cooperating agencies, private organizations and the flyway councils. This plan is scheduled for completion in September 1991.

North American Wetlands Conservation Act

The single most significant event since the signing of the Plan was the enactment of the North American Wetlands Conservation Act (Act), signed by President Bush on December 13, 1989. This legislation gave U.S. Congressional recognition to the Plan and provided for wetlands conservation across the continent. It provided a significant core of federal funding to stimulate public/private partnerships and it authorized a means of transferring U.S. funds to Canada and Mexico. It also broadened the geographic and biological scope of the Plan.

This legislation was authored by supporters who believed in the basic principles of the Plan and wanted to promote its implementation. Several members of the U.S. Implementation Board assisted in various revisions before the legislation was introduced in June 1989 by Senate Majority Leader Mitchell of Maine, and supported by Senators Burdick, Baucus, Chafee and Grassley. A companion bill was introduced into the U.S. House of Representatives on October 10, 1989, by Congressmen Conte, Davis, Dingell and Jones, and supported by Congressmen Bennett, Ridge, Stangeland and Studds. These two bills were merged and passed late in the November session of 101st Congress and signed by President Bush on December 13, 1989.

The Act encourages partnerships among public agencies and private interests to protect, restore and manage an appropriate distribution and diversity of wetlands ecosystems and other habitats for migratory birds and other fish and wildlife. Its funding sources provide up to $15 million annually from general appropriations, about $14 million annually from interest gained from short-term investments of Federal Aid to Wildlife Restoration receipts, and an estimated $900,000 from fines, forfeitures and penalties from violations of the Migratory Bird Treaty Act. In its first year as a budget item, the Act received the full appropriation, although the penalties receipts were held back. An additional $7 million will be gained for projects in U.S. coastal states starting in FY 1992 from the 1990 Coastal Resources Act, championed by Senator Breaux of Louisiana. During its second year of enactment, the Act is expected to provide a base of at least $35 million and another minimum of $37 million of matching state and private funds. In addition, Canadian and Mexican projects are partially matched by in-country contributions.

After administrative costs, at least $30 million and as much as $42 million per year of U.S. federal, private and state funds could be directed to wetlands conservation projects in Canada and Mexico where they will be matched again by in-country funds or in-kind contributions. This is because the Act requires that at least 50 percent, but nor more than 70 percent, of the funds available each year shall go to these two countries. From $16–$22 million, including the $7 million for coastal states, will be available each year as federal matching funds for U.S. projects.

The Act established a North American Wetlands Conservation Council (Council), appointed by the Secretary of the Interior, to recommend projects to the U.S. Migratory Bird Conservation Commission (Commission) for approval. In addition to the Director of the U.S. Fish and Wildlife Service and the Executive Director of the National Fish and Wildlife Foundation, four state fish and wildlife agency heads, and three private conservation organizations were to be named. Interior Secretary Manual Lujan, on February 21, 1990, announced the appointment of the first Council, and U.S. Fish and Wildlife Service Director John Turner assigned the coordination responsibilities to the U.S. North American Waterfowl and Wetlands Office. The Council elected Matt Connolly, Executive Vice President, Ducks Unlimited, Inc. as the chair. It developed operating procedures, solicited proposals and sent its first set of recommendations to the Commission in September 1990, and a second list to the Commission on January 1, 1991. During this same period, the Canadian Minister of Environment established a Canadian Wetlands Conservation Council to recommend Canadian projects to the Secretary of the Interior for consideration by the Council.

To date the Council received 168 proposals from Canada, Mexico and the U.S., totaling $42 million of Act funds. Of these, 25 have been approved for Canada for a total of $8.6 million; four for Mexico totaling $160,000; and 41 projects in the U.S. totaling $13.7 million. Table 1 lists the general distribution of the projects approved to date. These projects included wetlands acquisition and wetlands enhancement activities for provincial, state, private conservation organizations, the U.S. Fish and Wildlife Service, the Bureau of Land Management, and the U.S.

Table 1. Acreages protected, restored and/or enhanced in the habitat joint ventures in Canada and the U.S., 1986–90[a]

	Acres			
	Protected	Restored	Enhanced	Other MAs[b]
Canada				
Eastern Habitat	10,200	400		23,800
Prairie Habitat	112,00	5,000	85,000	
(Subtotal 235,000)	122,200	5,400	85,000	23,800
United States				
Atlantic Coast	167,000	2,500	4,900	
Central Valley	24,400	7,500	48,000	
Gulf Coast	49,700	1,500	39,100	87,100
Low Miss Valley	103,000	20,000	62,000	57,800
Lo Gr Lks/St La Ba	4,000	3,000	500	—
Prairie Pothole	45,000	18,800	9,000	49,000
Playa Lakes			200	200
(Subtotal 803,400)	393,100	53,300	163,700	194,100

[a]Tentative summary data through 1990. May be conservative with some overlap with acreages shown under other management agreements. Final data will be included in 1990 annual report.
[b]Other management agreements.

Army Corps of Engineers. Projects totaling another $9.2 million will be proposed for approval at the June Commission meeting.

In February, the Council distributed a new solicitation package requesting proposals for FY 1992 funds. Sponsors are encouraged to apply to any time as the Council will submit their recommendations to the Commission three times each year.

Ancillary Programs

As implementation of the Plan has progressed the past three years, many new cooperative programs, new partnership arrangements and new legislative actions have evolved in both countries to strengthen support for the Plan.

United States

The principal actions to date in the U.S. that directly or indirectly influence achievement of Plan objectives include:

- Emergency Wetlands Resources Act, 1986.
- U.S.—Canada—Mexico Tripartite Agreement, 1988.
- North American Wetland Conservation Act, 1989.
- National Wetlands Priority Conservation Plan, 1989.
- Non-indigenous Aquatic Nuisance Prevention and Control Act, 1990.
- Reauthorization of 1990 Farm Bill.
- Wetlands Action Plan, U.S. Fish and Wildlife Service, 1990.
- Interagency agreements between U.S. Fish and Wildlife Service, and the Department of Defense, Department of the Army (COE), Bureau of Reclamation, Bureau of Land Management, Forest Service, Soil Conservation Service and the national Association of Conservation Districts; all specific to the plan and stressing wetland protection and enhancement.
- Establishment of new trust fund, "Wetlands America," by the Ducks Unlimited Foundation.
- Expansion of matching grant program by the National Fish and Wildlife Foundation.

Canada

The following supportive actions have occurred:

- Development of new federal policy on wetland conservation.
- Sustaining Wetlands Forum (April 1990) produced 73 recommendations that were sent to the National Roundtable on Environment and Economy, which requested the Minister of Environment to follow-up through the Canadian Wetlands Conservation Council.
- Announcement of the Green Plan that includes many recommendations and promises for wetlands protection and wildlife programs. It also includes a federal commitment to support the Pacific Coast Joint Venture.
- Five-year funding authorization of $30 million by Cabinet for the Plan.
- Agriculture Canada, through the Crop Insurance Act and Soil and Water Conservation Program, is contributing greatly to implementation of programs under the Prairie Habitat Joint Venture.
- Implementation of the Prairie Care Program by Ducks Unlimited Canada.

- Implementation of the Prairie Farming Program by the North American Wildlife Foundation.
- Other provincial actions to establish organizational entities for planning and financial management of matching funding arrangements, new private lands initiatives, and public outreach programs.

Mexico

Since the signing of the Tripartite Agreement between Mexico, U.S. and Canada in March 1988, the U.S. Fish and Wildlife Service funded 12 projects for $126,000. These first projects were studies of development impacts, inventories, sustainable development and conservation education programs. Recently, Dr. de la Garza, Director General, Secretariat of Urban Development and Ecology (SEDUE), has provided a list of the 27 priority wetlands in Mexico for migratory birds and participated in the development of a set of principles for the expansion of the Plan to include Mexico. The principles include a stepping-stone biological corridor concept, the protection and management of wetlands on a watershed basis, and the integration of sustainable development concepts in any protection action. The North American Wetlands Conservation Act also directs the U.S. Secretary of the Interior to invite and encourage Mexican officials to participate in revisions of the Plan.

As of February 26, 1991, four additional projects were approved under the Act for funding of $160,500 for protection and enhancement of 261,000 acres (105,700 ha). Matching funds provided an additional $340,000.

Summary of Accomplishments

By October 1989, nearly 600,000 acres (240,000 ha) of wetlands and associated uplands had been protected, restored or enhanced in the existing habitat joint ventures in Canada and U.S. In addition, both countries have agricultural incentive programs that encourage landowners to modify land-use practices to increase benefits to wildlife.

As of January 1990, the initial seven U.S. Joint Ventures had about 45 active projects underway, with 210 additional identified and in some stage of planning. In Canada, 17 projects were underway, with 30 more on the drawing boards. The number of active projects increased to more than 140 during 1990.

We are in the process of summarizing accomplishments during 1990, but do not have project acreage and funding details tabulated from all joint ventures. As shown in Table 1, the tentative accomplishments during 1990 will likely increase the acreage of habitat affected to more than 1,038,000 acres (420,200 ha).

During 1989, the partners involved contributed about $81 million to the efforts on U.S. joint ventures as indicated in Table 2. It is estimated that total funding available during 1990 will exceed $90 million.

Included in the above estimates for 1990 are the first new accomplishments under the North American Wetland Conservation Act for projects in Canada, U.S. and Mexico. Through March 12, 1991, this included four projects in Mexico, 25 in Canada, and 41 in the U.S.; with $22.4 million Act funds, $42.8 million partner funds, for a total project cost of $65.3 million. Further details are shown in Table 3.

Table 2. Contributions to North American Waterfowl Management Plan by partners in U.S. joint ventures—1989.

Partner	Contribution
U.S. Fish and Wildlife Service	$14,700,000[a]
States	28,264,000
Other government	9,846,000
Nongovernment organizations	26,144,000
Corporations	392,000
Individuals	1,999,000
Total (U.S.)	$81,345,000

[a]Additional operations and management costs supported by USFWS regions but not identified as plan contributions.

Table 3. 1990–1991 projects approved for North American Wetlands Conservation Act funding.

Area	Number of projects	Act funds $(000)	Partner funds $(000)	Project cost $(000)
Mexico	4	161	364	525
Eastern Habitat Joint Venture	12	1,636	3,694	5,330
Prairie Habitat Joint Venture	13	6,948	13,350	20,298
Prairie Pothole Joint Venture	15	2,900	4,477	7,377
Atlantic Coast Joint Venture	4	4,030	5,182	9,212
Lower Great Lakes/St. Lawrence Basin Joint Venture	3	650	2,081	2,731
Lower Mississippi Valley Joint Venture	5	912	2,041	2,953
Gulf Coast Joint Venture	3	707	1,098	1,805
Playa Lakes Joint Venture	1	100	100	200
Central Valley Joint Venture	3	3,603	9,602	13,205
Areas Outside Joint Ventures	7	789	876	1,665
Totals	70	$22,436[a]	$42,865	$65,301

[a]As of March 12, 1991.

Future Actions

Update Plan

The Plan is to be updated at five-year intervals, with the first revision due in 1991. The North American Plan Committee decided that a major rewrite of the Plan would not be done at this time. Instead, an Addendum will be prepared to incorporate new information obtained since the Plan was approved in 1986. This will include clarification of habitat and population objectives; new legislative action and conservation agreements; increased emphasis on benefits to other wetland wildlife and related wetland values; other wetland initiatives and their linkage to the Plan; increased emphasis on certain related management issues such as law enforcement, research needs and evaluation; 1991–1995 schedule for additional joint ventures; and development of programs with Mexico.

Additional Joint Ventures

The next series of joint ventures to come on line during 1991–1995 are: Pacific Coast, planning started 1990, operational 1991–1993; Rainwater Basin, planning underway, operational 1993; Upper Mississippi River-Great Lakes, planning underway, operational 1993; Great Plains, planning 1993; Intermountain West, planning 1993. The general areas are shown in Figure 1.

Evaluation System

An evaluation system consisting of tracking of habitat accomplishments, monitoring of population response and measurement of program accomplishments is being developed. The tracking phase is being field-tested this year. A Continental Evaluation Team is in the process of developing procedures for monitoring population response by waterfowl and other migratory birds to habitat changes at regional and joint venture levels. A draft plan should be available by October 1991. Corresponding computerized databases will be developed and coordinated with population information systems now used by the Office of Migratory Bird Management and related wetland inventory systems in the U.S. and Canada.

Research Needs

As joint venture plans evolve and project plans become more definitive, a variety of information gaps and research needs are being identified. While this important area needs considerable more review and agreement on priorities, the principal categories of need include:

- Improved survey and census techniques.
- New methodology for measuring population response by waterfowl and other migratory birds to regional and local habitat changes.
- Evaluation of wetland restoration efforts to identify priority locations, most effective methods and longer-term vegetative response.
- New approaches to integrated predation management.
- Disease prevention and control.
- Effects of agricultural chemicals on reproductive capabilities of waterfowl and other migratory birds.
- Qualitative recovery of wetland communities following drought.

- Reproductive capability of principal species of ducks to recover from low population levels.
- Indirect relationships between measured response of waterfowl to habitat changes and benefits accruing to other nongame migratory birds.
- Evaluation of migratory bird response to changing agricultural programs and practices on private lands.
- Determine cost-effectiveness of upland management programs in enhancing recruitment rates for prairie ducks. Address extensive and intensive management practices, and optimum habitat unit size.
- Develop better techniques to monitor land-use changes over longer periods of time, in and outside of joint ventures and specific projects.
- Breeding ecology and population dynamics of other key duck and goose species or populations.
- Future role and impact of wild waterfowl rearing and release programs.

Public Support

Enthusiasm and support for the Plan continue to gain momentum at all levels, with public involvement increasing most dramatically at the project level. The availability of new funding under the NAWCA has stimulated participation by new partners to meet the matching funding requirements, but we still need new sources of nonfederal dollars to meet the 50–50 match. Increases in regular federal, provincial and state operating budgets to support Plan activities have been slower in developing, but are still significant. It is estimated that during the 12 years remaining for the anticipated full implementation of the Plan, it will require about $120 million annually to achieve the habitat objectives alone. Operational budgets will also have to be increased proportionally.

In order to keep the momentum going it will also be essential that the agencies and organizations involved greatly expand their communications capabilities. While considerable effort has been devoted to raising public awareness and stimulating citizen action, much remains to be done to carry our messages to the general public.

The bright spot for wetlands and migratory birds has been the progress made by our many partners to date in initial implementation of the Plan through the joint venture process. As we meet here today, spring is returning to the Prairie Region of the U.S., Canada and other northern areas. Migratory birds are moving up against the freeze line. The prairies are still suffering from a 8–12 year drought period, with some recovery beginning in Alberta and the northern parklands of the three prairie provinces. What kind of habitat will waterfowl and other migratory birds find this year? What about 10 years from now? Water will eventually return to the Prairie Region. When it does, we will need quality nesting habitat and sufficient numbers of breeding birds to permit as rapid a recovery of populations as possible.

As we have urged previously, let's put our talents and collective support behind the Plan. We are indeed involved in one of the greatest conservation challenges of this century, and we must begin planning for the 21st century now.

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Geese of the Western Palearctic: Present Status and Challenges for Research and Management in the '90s

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Introduction

Geese breeding in a range from northeastern Canada in the west to North Siberia in the east spend the winter in the temperate and mediterranean zone of the Western Palearctic. Increasing awareness of the needs for conservation and management of the populations and their wintering sites in the 1950s prompted monitoring schemes and research programs in the Western Palearctic, with the overall aim to improve understanding of the flyway populations and form a basis for management and legislative initiatives.

This presentation summarizes the status of geese wintering in the Western Palearctic and related conservation and management problems. Facing the future, the paper addresses that, given the likelihood of management problems to exacerbate due to continued growth of populations, a fly-way based approach is the key word to goose research and management in the 1990s (*see also* Pirot and Fox [1990] for Western Palearctic waterfowl in general).

Goose Count Network and Ringing

Surveys of wintering geese are organized nationally by research institutes or organizations (at present in 22 countries), with international coordination through the Goose Research Group of the International Waterfowl and Wetlands Research Bureau (IWRB). Counts are mainly conducted by networks of dedicated volunteers counting from the ground. The mid-January count has traditionally been the backbone of the surveys but, to achieve better population estimates, special counts at other times of the winter season are arranged for many populations. Coverage of the counts has generally been good in western and central Europe, whereas in the eastern part it has been more fragmentary.

Since 1989, counts have been centralized in a computerized database with the aim of enhancing the production of population trends and analyzing regional variations in goose numbers in relation to weather conditions and environmental factors.

Age counts conducted for several populations each autumn have, combined with the population counts, enabled crude analyses of population dynamics (e.g., Ebbinge 1985, Fox et al. 1989, Underhill and Summers 1990).

Since the 1950s, ringing has been an important tool enhancing identification of flyway populations and, later, analyses of survival rates. Today, traditional metal rings are often supplemented by use of plastic legrings or neckcollars with engravings, allowing resightings of individual live birds at distance and giving rise to more detailed analyses of patterns of dispersal, population dynamics and individual behavior (e.g., Owen 1984, Teunissen et al. 1985, Wilson et al. 1991, Ebbinge et al. 1991). At present, more than 42 schemes are in operation, covering 11 species/subspecies (Madsen 1991a).

Status and Recent Trends

The first reliable accounts of the numbers and distribution of geese in the region were published by Timmerman et al. (1976) and Ogilvie (1978), followed up by reviews by Madsen (1987, 1991b).

Nine goose species occur in substantial numbers in the Western Palearctic, forming 24 more or less well-defined populations and totaling approximately 2 million birds in the mid-1980s (Table 1) (Madsen 1991b).

Since the 1950s–1960s, 19 out of 22 populations for which the trend is known have increased in numbers while one has remained relatively stable and two have decreased.

In several of the populations which were initially increasing, the rate of increase has been leveling off in the 1980s, e.g., the Svalbard populations of pink-footed goose (*Anser brachyrhynchus*) and barnacle goose (*Branta leucopsis*) and two of three brent goose (*Branta bernicla*) populations. Other populations, e.g., the Icelandic populations of pink-footed goose and greylag goose (*Anser anser*), the Siberian population of white-fronted goose (*Anser albifrons*) wintering in northwestern Europe and two populations of introduced Canada goose (*Branta canadensis*) have continued their growth at the same high rate as in the previous decades.

The population of white-fronted geese wintering in central Europe has declined from more than 300,000 in the 1950s to about 60,000 in the 1980s (Dick 1990). More critically, the population of lesser white-fronted geese (*Anser erythropus*), breeding in Scandinavia-northern Russian and staging/wintering in central and southeastern Europe has undergone a tremendous decline in the same period, recorded both at the Scandinavian breeding grounds where the population has almost been extirpated (Norderhaug and Norderhaug 1984) as well as at the staging/wintering grounds (Sterbetz 1982). Encouragingly, in the central breeding range, Taimyr in the USSR, the population seems to have been stable during the last two decades, and the population staging/wintering in Kazakhstan/Caspian Sea is estimated at 100,000 birds (Vinogradov 1990).

The Svalbard population of light-bellied brent goose (*Branta bernicla hrota*), which numbered 50,000 individuals or more early this century but declined sharply in the first decades, is one of the smallest goose stocks in the world with only 2,000 birds in the 1960s. However, in the 1970s it recovered to a present number of 4,000–5,000 (Figure 1) (Madsen 1987 and unpublished).

Summing up, the goose counts have shown that overall numbers have almost doubled over the last 10–15 years.

Assuming that there has been no net exchange of individuals between populations, the striking increases which have affected most populations over the last 20–30 years can potentially be attributed to an improved breeding success and/or a reduction in mortality rates. Changes in breeding success based on analyses of age counts, population counts and ringing have been examined in nine populations: two populations of pink-footed goose (Ebbinge et al. 1984, Fox et al. 1989), European white-fronted

Table 1. Population estimates of geese breeding and/or wintering in the western Palearctic in the 1980s. Estimates are five-year means or the most recent estimate. Sources: *see* Madsen (1991b).

Species/subspecies/ population	Breeding range	Winter range	Estimated population	Trend in 1980s
Bean goose				
Anser f. fabalis	N Scand./Siberia	NW Europe	80,000	increase
Anser f. rossicus	N Russia/N Siberia	Europe	300,000	increase?
Pink-footed goose				
Anser brachyrhynchus	Iceland/E Greenland	Britain/Ireland	110,000	increase
Anser brachyrhynchus	Svalbard	NW Europe	25,000	stable
White-fronted goose				
Anser a. albifrons	Siberia	NW Europe	400,000	increase
Anser a. albifrons	Siberia	Central Europe	100,000	decrease
Anser a. albifrons	Siberia	Black Sea/Turkey	250,000	stable?
Anser a. flavirostris	W Greenland	Britain/Ireland	22,000	increase
Lesser white-fronted goose				
Anser erythropus	N Scand./Siberia	Black Sea/W Asia	25,000–50,000?	decrease
Greylag goose				
Anser anser	Iceland	Britain/Ireland	100,000	increase
Anser anser	N Scotland	N Scotland	2,000	stable
Anser anser	Brit. Isles (feral)	Britain/Ireland	14,000	increase
Anser anser	NW/Central Europe	Spain/Netherlands	120,000	increase
Anser anser	Central Europe	N Africa	20,000	stable
Anser anser	Black Sea	Black Sea	20,000	uncertain
Canada goose				
Branta canadensis	England (introduced)	England	50,000	increase
Branta canadensis	Scand. (introduced)	Baltic Sea	50,000	increase
Barnacle goose				
Branta leucopsis	N Russia, Baltic	Netherlands	70,000	increase
Branta leucopsis	E Greenland	Scotland, Ireland	32,000	stable
Branta leucopsis	Svalbard	Scotland	10,000	increase
Brant goose				
Branta b. bernicla	N Siberia	W Europe	170,000	increase
Branta b. hrota	N Canada/ N Greenland	Ireland	20,000	stable
Branta b. hrota	Svalbard	Denmark/ E England	4,000	increase
Red-breasted goose				
Branta ruficollis	N Siberia	Black Sea/ Caspian	35,000	increase

goose (Ebbinge 1985), Greenland white-fronted goose (*A. a. flavirostris*) (Wilson et al. 1991), Icelandic greylag goose (Fox et al. 1989), three populations of barnacle goose (Owen 1984, Ebbinge 1985, Fox and Gitay 1991), and dark-bellied brent (Ebbinge (1985). In none of these has annual recruitment changed significantly over

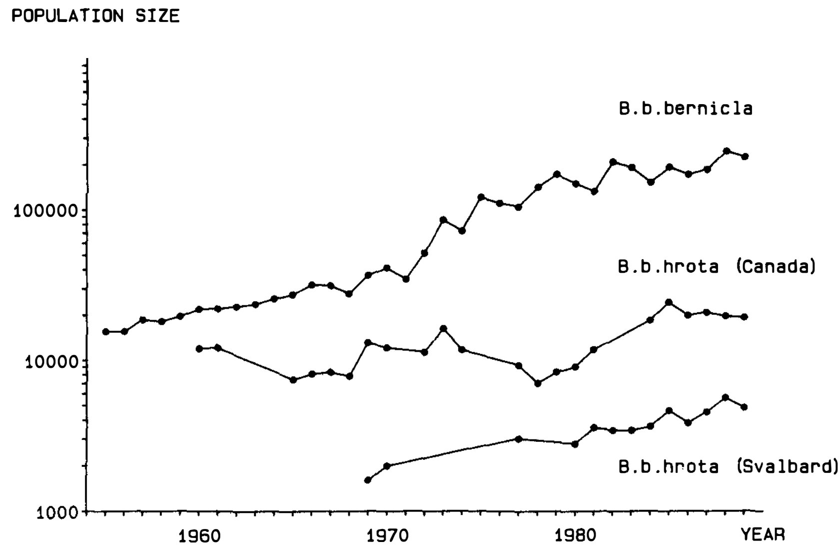

Figure 1. The development of the three brent goose populations wintering in northwestern Europe: dark-bellied brent (*Branta b. bernicla*), light-bellied brent (*B. b. hrota*) breeding in northeast Canada and wintering in Ireland, and light-bellied brent breeding in Svalbard and wintering in Denmark. From the IWRB Goose Research Group.

the last 20–30 years, implying that increases in population sizes have been caused by reduction in mortality.

Indeed, in several populations mortality rates have dropped significantly during the last two to three decades. The reason for this has primarily been attributed to a general relaxation of shooting pressure due to legislative regulation of open seasons and a more effective refuge network. That goose shooting has been an additive mortality factor is shown by the immediate positive development in populations following protection: dark-bellied brent (Figure 1) (Ebbinge 1991); Greenland white-fronted goose (Wilson et al. 1991); and Svalbard barnacle goose (Owen and Norderhaug 1977). Another factor that may have enhanced survival, yet remains to be documented, is the increasing goose usage of agricultural land as feeding habitat during winter, assuring the geese a better food supply during this critical time of the year when natural resources may be in short supply.

Despite the long-term collection of population parameters through counts and ringing, attempts to predict future population development and carrying capacity have been rather unsuccessful, with populations breaking through the suggested ceilings. Apart from the indirect evidence which comes from the tendency of some population increase rates to level off, there are only vague signs of density-dependent processes affecting population growth at present. Only in the Svalbard barnacle goose is there evidence of food limitation on the spring staging areas and the breeding grounds which affects nesting output and juvenile survival (Prop et al. 1984, Owen and Black 1989).

The causes of the declines in the lesser white-fronted goose and the central European winter population of white-fronted goose remain obscure. Intensification of farming practices, turning natural steppe into winter cereal and maize fields is a common explanation (Sterbetz 1982, Dick 1990). It cannot be excluded, however, that the white-fronted goose population has shifted its winter distribution, either to the northwest or to the southeast. To improve the Scandinavian breeding population of lesser white-fronted geese, reintroductions are carried out. The idea is, with the aid of barnacle geese as foster parents, to change the migration route to northwestern Europe, where the birds will attain better conservation status and have a better food supply than in southeastern Europe (von Essen 1991). The project rests on the assumption that the critical factors responsible for the decline lie on the wintering grounds and not on the breeding grounds, an assumption which has not yet been thoroughly examined.

The small and vulnerable Svalbard population of light-bellied brent goose seems to have a limited scope for further development, being "ecologically trapped" in the southeastern corner of Svalbard with a high predation pressure, limited food supplies and, possibly, increasing competition from an expanding barnacle goose population (Madsen et al. 1989, unpublished).

Management Problems

The combination of increasing goose populations, their convergence on arable land, and an increasing tendency in the farming community to grow crops which are vulnerable to goose grazing, has led to conflicts on local scale between geese and farmers in most of the Western Palearctic flyway range states which hold substantial numbers of staging or wintering geese. The most severe damage problems have arisen in northwestern Europe, being most profound in the Netherlands and Britain where the highest concentrations of geese are found (Rüger 1985).

Despite the fact that assessment of goose damage has been a theme for intensive research for more than 20 years, general, precise and practical methods have not been elaborated, nor has it been possible to generalize impact assessment (Bruinderink 1989, Owen 1990, Patterson 1991). Partly due to these technical problems, partly due to lack of national and international management policies, it has been difficult to work out an efficient and fair compensation system. In some range states, e.g., the Netherlands, large amounts of compensation for damage is payed annually, with consequent and undesirable inflation of the payments (van Eerden 1990). In other countries, e.g., Britain, it is now the policy to prevent damage by scaring the geese from the crops to alternative feeding areas, in extreme cases combined with licensed shooting over vulnerable crops (Owen 1990). In Belgium it has been the policy to lessen the conflicts by gradually banning shooting which has allowed the geese to use an increasing area, leading to a dispersal from the areas of high concentration (Meire et al. 1988).

Future Research and Management Needs

The 1980s saw a boost in Western Palearctic goose research, with extension of monitoring programs as well as advanced studies of population dynamics, behavior, habitat ecology and feeding energetics during different phases of the annual cycle (reflected by the Proceedings from the International Symposium on Western Palearctic Geese (Fox et al. 1991).

A prerequisite for future population studies, as well as for goose conservation and management schemes, is effective population monitoring. The setting up of a central IWRB Goose Research Group database covering monitoring of all Western Palearctic goose populations and the design of special population counts will hopefully prove to be the tool that is needed. The success will depend heavily on the feedback from the database to the network. The publication of a newsletter, now replaced by a biannual IWRB Goose Research Group Bulletin (first issue published February 1991) is one of the ways in which it is hoped to forward this process.

One of the key questions from authorities managing goose damage to goose biologists in the 1990s will undoubtedly be: what is the carrying capacity of populations? Monitoring of populations by counts and age counts has provided basic knowledge to our present understanding of population dynamics. These studies have, however, been inadequate to enable long-term modeling of the populations. If we want to get closer to an answer of what regulates populations, we have to combine population counts with independent estimates of population parameters derived from ringing/individual marking, as proved by the intensive studies of the Svalbard and Russian populations of barnacle goose (e.g., Owen 1984, Owen and Black 1989, Ebbinge et al. 1991), and as suggested by Fox et al. (1989). Furthermore, interpretability will highly gain from field studies of factors affecting breeding success. So far, most of the field experience has been restricted to northern Atlantic populations, whereas information is scarce regarding the populations nesting in northern Russia and Siberia.

A very important step forward which will enhance these studies has been the achievement of much improved contacts between scientists from the western and eastern parts of the region during recent years. resulting in improved communication (*see* Matthews 1990), exchange of data and agreements about cooperative projects including exchange of scientists. Because many of the goose populations are shared between the "East" and "West," these contacts and joint projects are essential for progress in our understanding of the fly-way populations.

Contrary to North America, where estimation of harvest magnitude and distribution as well as analyses of derivation of birds harvested are practiced routinely on an annual basis (e.g., Boyd 1990, Trost et al. 1990), there exists no full picture of the goose harvest and harvest rates for the Western Palearctic. Collection of harvest data is practiced in some countries but differences in procedures and time lag in data processing and international coordination prevent an effective operational use for managing of shooting (*see* Landry 1990). Even though IWRB has taken steps to forward the process, it is anticipated that it will take a long time before full coverage is accomplished.

On the question of goose damage and possible solutions to prevent it, it seems that we have got to a gateway with three options: (1) we can "manage" populations to a level where damage problems are no longer severe; (2) we can allow goose populations to grow to carrying capacity without interference, and solve problems by compensation; or (3) through a refuge area network with good quality food supplies, geese can be attracted/disturbed to the refuges, away from the crops (Owen 1990). Solution (1) is called for by some representatives from the farming communities but is largely unacceptable to general public opinion and also difficult to practice. Solution (2) is, as the Dutch example demonstrates, difficult to manage, expensive and does not provide a long-term sustainable solution. Solution (3) is costly too, but since the farming community in Europe is currently seeking to reduce cereal yields and setting aside farmland to alternative purposes, there are considerable opportunities (*see* Owen [1990] for a full discussion).

As it has been demonstrated above, with few exceptions goose populations in the Western Palearctic have been extremely successful in terms of population development during the recent decades. Future management/conservation strategies will have to focus on, on the one hand the restoration of threatened populations and their habitats and, on the other hand how non-threatened populations and their habitats can best be integrated into modern human physical and recreational (including hunting) land use and planning. Moreover, with our knowledge of dispersal of fly-way populations, it has for a long time been recognized that management needs to be planned on a fly-way basis. For decades this has been common practice in North America (Nelson and Bartonek 1990); in Europe, however, a formal platform has hitherto been missing and very few examples of integrated management exist. With The Convention for the Conservation of Migratory Species of Wild Animals (Bonn Convention 1979) ratified by 15 parties in 1983, and the decision of the preparation of an agreement and management plan for western palearctic waterfowl under the Bonn Convention (to be ready by the end of 1991), an instrument for fly-way based management is now at hand.

Surely, due to differences in administrative, cultural and political structures in the range states involved, an integrated management approach will have to overcome a lot of complex problems before it can be operative (Boere 1990). Geese which make such a traditional use of sites and which can be divided into well-defined populations would be a good model starting point.

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Conservation and Genetic Resources in Waterfowl

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Introduction

Conservation of migratory wildlife resources is a multidimensional problem. Extrinsic factors, such as habitat quality or quantity and barriers to dispersal or gene flow, interact with behavioral, physiological and genetic attributes of avian species to determine their survival (Baker and Fox 1978). Perhaps the least understood aspects of migratory waterfowl are those involving genetic variation and structure (Anderson et al. 1991). Currently few data exist which quantify the extent and partitioning of genetic variation within or among waterfowl populations (Van Wagner and Baker 1986, Novak et al. 1989). Data on genetic variation in waterfowl species might be used to meet management objectives related to taxonomic, demographic and conservation interests.

Studies of genetic variation provide insights to breeding structure, gene flow and population subdivision in waterfowl species (Barrowclough 1980). Unique alleles or DNA fragment lengths may be used to identify waterfowl populations or different taxonomic groups, thus greatly aiding harvest and management efforts (Ankney et al. 1986, Avise et al. 1990). Temporal changes in allele frequencies might be used to detect movement of waterfowl populations within their wintering grounds, between breeding areas, or among flyways as has been accomplished with other migratory species (Svoboda et al. 1985, Millar 1987). Effects of specific alleles and genotypes can be assessed for their contributions to fitness in waterfowl as in other avian species (Frelinger 1972, Redfield 1974). Results of genetic analyses may allow managers to predict the impacts of selection in heterogeneous environments on parameters such as survival and reproduction, ultimately leading to improved conservation and management of waterfowl.

Our objectives were to compare existing estimates of genetic variation in waterfowl species against our estimates of genetic variation in four species of dabbling ducks and to discuss how genetic data can be used in waterfowl conservation and management.

Electrophoretic Methods

Samples of liver and muscle from mallards (*Anas platyrhynchos*; N = 136), American wigeon (*A. americana*; N = 66), northern pintails (*A. acuta*; N = 61), and green-winged teal (*A. crecca*; N = 80) in the Southern High Plains (SHP) region of Texas (Bolen et al. 1989) were obtained during fall and winter of 1987–88. Tissues were stored at −60°C for later electrophoretic analysis.

Electrophoretic analyses were performed, using liver and muscle tissues, to determine which enzymes could be resolved and scored consistently. Forty-nine enzymes were surveyed for genetic variation, in each of the four study species, using the following buffers: Amine Citrate (gel ph 6.1/tray ph 6.1), JRP (7.1/7.1), Lithium Hydroxide (8.1/8.4), Poulik (8.2/8.7), Tris Citrate (8.0/8.0), Tris HCL (8.2/8.5), and Tris Maleate (7.4/7.4) (Selander et al. 1971, Clayton and Tretiak 1972, Harris and Hopkinson 1977). Thirty enzymes were resolved and surveyed for mallards, 27 for American wigeon, 23 for northern pintails and 21 for green-winged teal. Additional loci were resolved for both northern pintails and green-winged teal, but constraints prevented scoring of these loci for all the birds. Mallards, American wigeon, northern pintails and green-winged teal collected on the SHP are classified as West Texas Anatini.

Locus abbreviations, quaternary structures and tissue/buffer combinations used to resolve the loci from West Texas Anatini are given in Table 1. Several peptidase substrates were used in the diagnostic electrophoretic surveys including glycyl-leucine, leucyl-glycyl-glycine, phenyl-alanyl-proline, leucyl tyrosine, and leucyl alanine peptidase. Genetic variation was observed but could not be scored at the catalase (CAT), esterase (EST 3), diaphorase (DIA 3), glutamate pyruvate transminase (GPT) and superoxide dismutase (SOD 1, 2 and 3) loci in the West Texas Anatini species.

Data from a literature survey of allele frequencies in waterflow species were used to calculate expected single-locus heterozygosity estimates ($h_i = 1-\Sigma x_i^2$, where x_i are the frequencies of the alleles observed at each locus, i [Crow and Kimura 1970]); for 2,401 species-locus combinations (Milne and Robertson 1965, Parker et al. 1981, Numachi et al. 1983, Oates et al. 1983, Patton and Avise 1985, Ankney et al. 1986, Van Wagner and Baker 1986, Evarts and Williams 1987, Corbin et al. 1988, Novak et al. 1989). Expected h_i's were calculated for each of the reported population specific species-locus combinations. All h_i estimates based on samples of <10 birds (N = 865) were not included in the analyses resulting in 1,536 species-locus combinations. Expected h_i's were also calculated for the 97 species-locus combinations in West Texas Anatini.

Waterfowl, for which data were taken from the literature, were classified as either Anatini Overall (all surveyed Anatini) or as Non–Anatini Waterfowl. Four hundred and eighty-eight species-locus combinations were surveyed in 11 species in the Anatini Overall group, and 1,048 in 33 species of Non–Anatini.

Number of alleles per locus (A) was recorded for each species-locus combination surveyed by us or reported by others. Data for A were divided into categories of 1, 2, 3 or ≥4 alleles per locus for each classification group (Figure 1). Expected h_i's for each species-locus combination were assigned to five categories for analyses (Figure 1). Log linear goodness of fit tests (G-Statistics; Sokal and Rholf 1981) were used to test for differences in the distributions of numbers of species-locus combinations in different A and h_i categories among the three classification groups of

Table 1. Thirty-three loci studied in wintering Anatini from the Southern High Plains region of Texas. Locus acronyms, species (S, M = mallard, T = green-winged teal, P = northern pintail, W = American wigeon), quaternary structures (QS), mean single locus heterozygosities (h), and mean numbers of alleles per locus (A) for the species are listed. Preferred tissues (T; L = liver and M = muscle) and gel buffers and their ph's are also given. Quaternary structures are defined as: 1 = monomer, 2 = dimer, 3 = trimer and 4 = tetramer.

Loci		Species	QS	h	A	T	Buffer[a]
Aat-1	Aspartate aminotransferase-1	M W P T	2	0.012	2.50	L	AC 6.1
Aat-2	Aspartate aminotransferase-2	M W P T	2	0.014	1.50	L	AC 6.1
Aco-1	Aconitase-1	M W P T	1	0.093	3.00	L	AC 6.1
Ada	Adenosine deaminase	M W P T	1	0.450	4.75	L	TM 7.4
Acp-1	Acid phosphotase-1	M W T	2	0.056	3.00	M	AC 6.1
Ck-1	Creatin kinase-1	M W	2	0.004	1.50	M	AC 6.1
Ck-2	Creatin kinase-2	M W	2	0.000	1.00	M	AC 6.1
CK-3	Creatin kinase-3	M W	2	0.033	2.00	M	AC 6.1
Dia-1	Diaphorase-1	M W P T	1	0.456	3.25	L	AC 6.1
Dia-2	Diaphorase-2	M P	1	0.266	2.50	L	AC 6.1
Est-1	Esterase-1	W	1	0.415	3.00	L	PK 8.2
Fh	Fumerate hydrotase	M T	4	0.145	2.50	L	JRP 7.1
Gpi-1	Glucose phosphate isomerase	M W P T	2	0.012	1.50	L	AC 6.1
Iddh	Iditol dehydrogenase	M P	4	0.072	3.00	L	TC 8.0
Idh-1	Isocitric dehydrogenase-1	M W T	2	0.285	2.33	M	TM 7.4
Idh-2	Isocitric dehydrogenase-2	M W P T	2	0.004	1.25	M	TC 8.0
Lap-1	Leucine aminopepidase-1	M W P T	1	0.142	2.75	L	AC 6.1
Ldh-1	Lactate dehydrogenase-1	M W P T	4	0.006	1.50	L	AC 6.1
Ldh-2	Lactate dehydrogenase-2	M W P T	4	0.009	1.75	L	AC 6.1
Mdh-1	Malate dehydrogenase-1	M W P T	2	0.003	1.25	L	AC 6.1
Mdh-2	Malate dehydrogenase-2	M W P T	2	0.026	2.25	L	AC 6.1
Me-1	Malic enzyme-1	M W	4	0.038	3.00	M	TC 8.0
Me-2	Malic enzyme-2	M W	4	0.228	3.00	M	TC 8.0
Mnr	Menadione reductase	W	2	0.117	3.00	L	AC 6.1
Mpi-1	Mannose phosphate isomerase	M W P T	1	0.022	2.50	L	PK 8.2
Np	Nucleoside phosphorylase	M W P T	3	0.482	4.25	M	AC 6.1
Pep-1	Peptidase-1	M W P T	1	0.263	4.50	L	AC 6.1
Pep-2	Peptidase-2	P	1	0.181	3.00	L	AC 6.1
Pgm-1	Phosphoglucomutase-1	M P	1	0.024	1.50	M	AC 6.1
Pgm-2	Phosphoglucomutase-2	M P	1	0.032	2.00	M	AC 6.1
Xdh	Xanthine dehydrogenase	M W P T	2	0.054	2.00	L	AC 6.1
G3pdh	a-Glycerophosphate dehydrogenase-1	M W P T	2	0.065	3.00	L	AC 6.1
Pgdh	6-Phosphogluconate dehydrogenase	M W P T	2	0.076	2.75	L	AC 6.1

[a]Gel buffers are: AC 6.1 = Amine-Citrate 6.1, TM 7.4 = Tris Maleate 7.4, PK 8.2 = Poulik discontinuous Tris-Citrate 8.2, JRP 7.1 = Tris-Citrate 7.1, and TC 8.0 = Tris Citrate 8.0.

ducks. The Dunn-Sidak correction ($\alpha = 1 - (1 - \alpha)^{1/k}$, where k = number of pairwise comparisons made and $\alpha = 0.05$, was used to control for type I error (Sokal and Rholf 1981).

Data from West Texas Anatini, Anatini Overall and Non-Anatini Waterfowl groups were pooled and mean multilocus heterozygosities ($H = (\Sigma h_{is})/n_{is}$, where h_{is} are means of single-locus heterozygosities (h_i) at each locus, i, calculated for a species, s, and n_{is} is the total number of loci observed for a species) were calculated for each

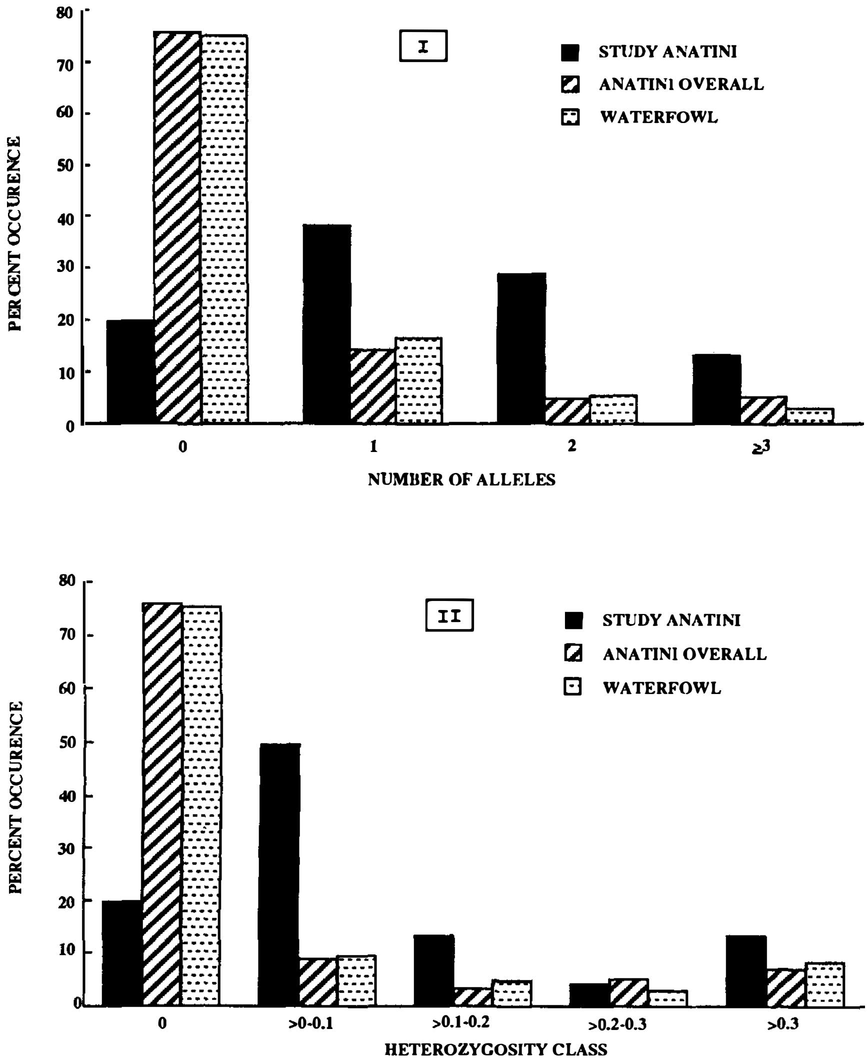

Figure 1. Percentage occurrence of species-locus combinations of various levels of heterozygosity (h_i; part I) and with different numbers of alleles per locus (A; part II) for West Texas Anatini, Anatini Overall and Non-Anatini Waterfowl. Heterozygosity values (h_i) are calculated as expected values based on allele frequencies.

species (N = 41; Table 2). Data for each locus were pooled across species and the overall mean of the h_i's for each locus surveyed was calculated ($H_L = ((\Sigma h_{iL})/n_{iL})$ where h_{iL} is calculated for each locus, L and n_{iL} is the total number of species-locus combinations observed for the locus). The H_L values for the loci were plotted against the number of times each locus was reported or observed to be polymorphic, with a common allele frequency of ≥ 0.95, divided by the total number of times the locus

Table 2. Names of 41 waterfowl species for which ≥ ten individuals have been electrophoretically surveyed for genetic variation are presented. Total number of loci for which each species has been surveyed at least once (N), average number of alleles per locus (A), and mean multilocus heterozygosity (mean of the means of the expected single-locus heterozygosity estimates for each locus surveyed; H) are given for each species.

Common name	Scientific name	N	A	H
Blue-winged teal	*Anas discors*	15	1.73	0.130
Barrow goldeneye	*Bucephala islandica*	14	1.14	0.025
Black brant	*Branta bernicla nigricans*	38	1.35	0.061
Black duck	*Anas rubripes*	33	1.40	0.049
Black scoter	*Melanitta nigra*	16	1.25	0.024
Bufflehead	*Bucephala albeola*	16	1.06	0.011
Canada goose[a]	*Branta canadensis*	37	1.62	0.069
Canvasback	*Aythya valisineria*	17	1.24	0.037
Cinnamon teal	*Anas cyanoptera*	18	1.50	0.084
Common goldeneye	*Bucephala clangula*	17	1.24	0.053
Common eider	*Somateria mollissima*	16	1.06	0.019
Common merganser	*Mergus merganser*	17	1.12	0.024
Eurasian wigeon	*Anas penelope*	10	1.10	0.010
Green-winged teal	*Anas crecca*	25	1.96	0.079
Gadwall	*Anas strepera*	16	1.25	0.057
Greater scaup	*Aythya marila*	18	1.17	0.025
Hooded merganser	*Mergus cucullatus*	16	1.00	0.000
Lesser whistling duck	*Dendrocygna javanica*	10	1.10	0.016
Lesser scaup	*Aythya affinis*	24	1.30	0.051
Mallard	*Anas platyrhynchos*	47	1.90	0.066
Mandarin duck	*Aix galericulata*	10	1.00	0.000
Mottled duck	*Anas fulvigula*	18	1.50	0.101
Oldsquaw	*Clangula hyemalis*	15	1.27	0.035
Northern pintail	*Anas acuta*	32	2.02	0.101
Red-breasted merganser	*Mergus serrator*	17	1.29	0.046
Ring-necked duck	*Aythya collaris*	16	1.25	0.068
Redhead	*Aythya americana*	18	1.39	0.079
Ross goose	*Anser rossi*	20	1.20	0.057
Ruddy duck	*Oxyura jamaicensis*	26	1.37	0.047
Northern shoveler	*Anas clypeata*	25	1.27	0.056
Snow goose[a]	*Anser caerulescens*	26	1.36	0.065
Flying steamer duck	*Tachyeres patachonicus*	10	1.87	0.182
Common name unknown	*Tachyeres leucocephalus*	9	1.44	0.094
Falkland flightless steamer duck	*Tachyeres brachypterus*	10	1.60	0.165
Magellanic flightless steamer duck	*Tachyeres pteneres*	8	1.75	0.200
Surf scoter	*Melanitta perspicillata*	15	1.07	0.006
Tufted duck	*Aythya fuligula*	10	1.00	0.000
White-fronted goose	*Anser albifrons*	18	1.11	0.021
White-winged scoter	*Melanitta fusca*	19	1.05	0.020
American wigeon	*Anas americana*	35	1.85	0.072
Wood duck	*Aix sponsa*	16	1.13	0.017

[a]Data for subspecies pooled for estimates.

was surveyed (P_L; Figure 2). Loci not clearly designated in the literature (e.g., MDH rather than MDH 1 or MDH 2) were not used in the plot of H_L versus P_L. Peptidase loci were defined by substrate type as follows: PEP 1, PEP 2 and PEP 3 use leucyl alanine; PEP 4, PEP 5, and PEP 6 use leucyl-glycyl-glycine. Esterase 1 and esterase 2 used α-naphthyl acetate as a substrate.

Electrophoretic Results

Mean h_i values among West Texas Anatini were 0.079 ± 0.03 (1 SE) for mallards, 0.11 ± 0.03 for American wigeon, 0.14 ± 0.05 for northern pintails and 0.11 ± 0.04 for green-winged teal. Average numbers of alleles per locus among the West Texas Anatini were 2.53 ± 0.23 for mallards, 2.37 ± 0.18 for American wigeon,

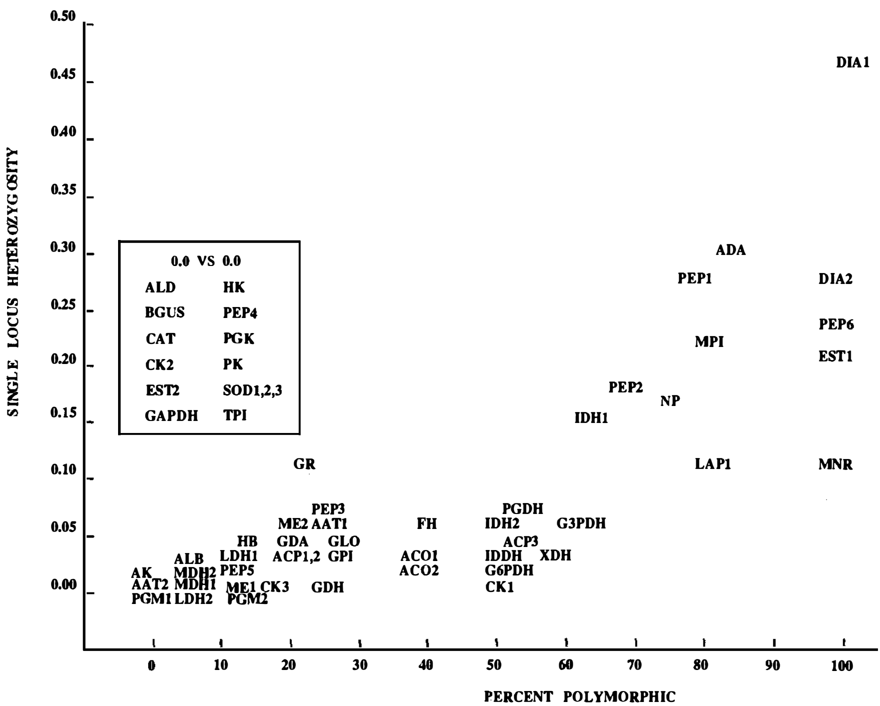

Figure 2. Summarization of mean single locus heterozygosities (H_L) values for 60 loci versus the percentage of times each locus was polymorphic (common allele frequency ≤0.95). Each H_L value was calculated as the mean of the expected single locus heterozygosity (h_i) values for the locus from the pooled data from all waterfowl species surveyed. Points are designated by their locus acronym as defined in the text or in Table 1. Loci acronyms not previously defined are: adenylate kinase (AK), albumin (ALB), aldolase (ALD), beta-glucuronidase (BGUS), glyceraldehyde-3-phosphate dehydrogenase (GAPDH), guanine deaminase (GDA), glutamate dehydrogenase (GDH), glyoxylase (GLO), glutathione reductase (GR), gluecose-6-phosphate dehydrogenase (G6PDH), hemoglobin (HB), hexokinase (HK), phosphoglycerate kinase (PGK), pyruvate kinase (PK) and triose-phosphate isomerase (TPI).

2.57 ± 0.26 for northern pintails and 2.48 ± 0.25 for green-winged teal. Percentages of loci surveyed which had a common allele frequency of ≤0.95 among the West Texas Anatini were 27 percent for mallards, 44 percent for American wigeon, 35 percent for northern pintails and 33 percent for green-winged teal.

Overall average numbers of alleles per locus were 2.41 ± 0.11 for West Texas Anatini, 1.43 ± 0.04 for Anatini Overall and 1.29 ± 0.02 for the Non-Anatini Waterfowl group. Overall averages for h_i values were 0.11 ± 0.01 for West Texas Anatini, 0.06 ± 0.01 for Anatini Overall and 0.05 ± 0.004 for Non-Anatini Waterfowl. Percentages of loci surveyed which had a common allele frequency of ≤0.95 were 32 percent for West Texas Anatini, 15 percent for Anatini Overall and 16 percent for Non-Anatini Waterfowl.

Differences were detected between the distributions of species-locus combinations in A and h_i categories of West Texas Anatini, and both the Anatini Overall and Non-Anatini Waterflow ($P < 0.001$; Figure 1). Distributions of species-locus combinations in A and h_i categories were not different between Anatini Overall and Non-Anatini Waterfowl (Figure 1).

The H values for the 41 waterfowl species ranged from two species with no variation detected to eight with H values ≥0.08 (Table 2). The overall mean of the H estimates was 0.058 ± 0.004. The plot of H_L versus P_L indicates which loci were both consistently polymorphic and high in genetic variation (Figure 2). Numbers of species-locus combinations used to calculate each H_L and P_L value ranged from 1 (MNR) to 71 (MDH1) with a mean of 23. Fourteen loci were monomorphic in all surveyed waterfowl species (Figure 2).

Electrophoretic Review

The largest source of genetic data for waterfowl species was taxonomic studies. Patton and Avise (1985) studied biochemical variation of proteins encoded by 17–19 loci of 26 species of waterfowl. Mean H of the species surveyed ranged from 0.00–0.08 with an overall mean of 0.03 (Patton and Avise 1985). Electrophoresis has been used to examine existing waterfowl phylogenies many times (Baker and Hanson 1966, Brush 1976, Morgan et al. 1977, Oates et al. 1983, Numachi et al. 1983). Electrophoretic analyses of 10–15 biochemical loci were used to determine phylogenetic relationships among four species of steamer ducks (Corbin et al. 1988). Observed H's in these species were high and ranged from 0.08–0.20 (Corbin et al. 1988). Ankney et al. (1986) investigated mallard/black duck hybridization and found little interpopulation genetic subdivision for either mallards or black ducks. The mean H for mallards in California (0.076), calculated from Ankney et al. (1986), is the highest reported for mallards prior to our study.

Bargiello et al. (1977) used serum esterases in the lesser snow goose to determine levels of genetic variation. They estimated that this species had only 0.143 polymorphic loci per bird and a low mean H of 0.01. Van Wagner and Baker (1986) reported estimates of mean H in 11 geographically distinct populations of Canada geese which ranged from 0.03–0.08. Novak et al. (1989) used genetic information from 28 loci to test the hypothesis that brant wintering in different areas represent one genetically panmictic population. The direct count H estimates for the surveyed populations averaged around 2 percent.

Owen and Bennet (1972) found mallard serum proteins to be low in genetic variation and, Parker et al. (1981) found that the mean H (20 loci) of 50 mallards wintering in the SHP region was very low (0.03) for such a wide ranging species. Genetic polymorphisms in egg white proteins were used to determine rates of gene flow among European populations of the eider (Milne and Robertson 1965). Evarts and Williams (1987) used electrophoretic data from eight polymorphic loci to estimate rates of multiple paternity in mallards.

Our overall estimates of H, A and percentage loci with a common allele frequency ≤0.95 in the West Texas Anatini are much higher than estimates for other Anatini or waterfowl species in general. A large proportion of the loci in our study were genetically variable increasing overall H. Our initial analyses were quite extensive, thus leading to the discovery of additional alleles and the presence of genetic variation at several loci previously unsurveyed for waterfowl species (e.g., DIA 1, DIA 2 and MNR). Sample sizes used in our analyses were much larger than those used in most taxonomic studies.

Our estimated overall mean H for waterfowl species (0.058) is close to the mean H reported by Nevo et al. (1984) of 0.051 ± 0.029 for 46 avian species. The plot of H_L versus P_L can be used to identify those loci which are consistently variable in waterfowl species. Loci that were consistently high in genetic variation and which may provide useful information for management are ADA, DIA 1 and 2, EST, LAP 1, MNR, MPI, NP, and PEP.

Application of Genetic Markers to Waterfowl Management

Our survey indicated a high level of genetic variation in waterfowl as revealed by allozyme analyses. Most of these data were collected using starch gel electrophoresis. This type of analysis may not be appropriate for certain types of problems, and other techniques (e.g., DNA probes or mitochondrial DNA analyses) could provide data with a more appropriate level of resolution. This resolution often comes at the price of not being able to analyze large numbers of individuals. Yet, certain questions cannot be answered with allozyme electrophoresis alone. For example, DNA and analyses might be useful in further differentiating among populations of Canada geese that differ slightly in their allozyme characteristics.

The existing data provide a baseline for evaluating future changes in the genetic characteristics of waterfowl species and evidence of considerable genetic variation in them. For management purposes, these data can be thought of as markers for studying (1) genetic structure within waterfowl populations, (2) relationships between genetic variation and functional characteristics, and (3) temporal changes in the genetics of waterfowl species. The usefulness of these markers is compromised as the level of selection that might be operating on them increases.

Genetic information is useful in helping to define management units, such as species (e.g., endangered), subspecies, stocks (e.g., flyways), populations, and other unique groups (Billingsley 1981). In some cases, these groups have legal status, and there is a need to be sure that they are truly unique rather than environmentally caused variants (*see* discussion below on Canada geese). Some groups could be in the process of losing their genetic identity through hybridization (e.g., mallards and black ducks). In these cases, DNA analysis of museum specimens could be used to determine the distinctness of the forms. This approach would establish a baseline and allow an evaluation of the genetic changes that have taken place during the rapid development of the human population in North America.

There are two basic ways that the genetic markers are useful in studying functional differences among groups and individuals. First, the genetic markers may be correlated to other characteristics that are of management interest (e.g., survival). These correlations could result from causal relationships, linkage of the genetic markers to other genes that determine the character of interest, breeding tactics (e.g., inbreeding vs outbreeding) that affect both the phenotypic and genotypic characteristics studied, or a combination of these or other factors. Second, the markers can be used to study the process by which differences are established or are enhanced by breeding structure (Novak et al. 1989). Movement between management units can often be inferred from the distribution of the genetic markers over space and through time, and this approach may be more efficient than labor intensive mark-release techniques.

Also, genetic information can be used to monitor changes in the genetic structure of management units. For example, waterfowl are declining in numbers in a variety of places. Low population numbers can result in a loss of genetic variability. The number of alleles per locus, proportion of polymorphic loci and multilocus heterozygosity will all decline in small populations, although the latter may be difficult to document due to sampling error associated with the limited number of loci surveyed. Loss of genetic variability would be of special concern in managing endangered or threatened species.

Genetic markers also can be used to mark shifts in the movement patterns of migratory populations. For example, concern has been expressed over the status of small Canada geese, the short grass prairie (SGP) and tall grass prairie (TGP) populations, in the Central Flyway. The geese that are assumed to be SGP winter primarily in the Playa Lakes Region of Texas, Colorado, New Mexico, Kansas, and Oklahoma and nest along the mainland of Canada from Queen Maud Gulf west to the Mackenzie River Delta and south into northern Alberta (Bellrose 1980). SGP geese also nest on Victoria and Jenny Lind Islands. TGP geese nest on Baffin Island in the northeast to Southhampton and King William Islands, along with the west coast of Hudson Bay northwest to the Queen Maud Gulf region. They are thought to winter primarily in eastcentral Oklahoma, coastal Texas, and northeastern Mexico.

Minimum counts of wintering SGP geese increased from 266,000 in 1988 to 376,000 geese in 1989 and prompted the U.S. Fish and Wildlife Service to increase the bag limit on SGP geese from two to three birds. In 1987, 306,000 TGP geese were counted during the winter surveys while in 1989 only 146,000 geese were counted. Reynolds et al. (1990:9) stated: "It is likely that part of this change [the TGP decline] is a result of mixing with Canada geese from the Short Grass Prairie population. This possibility is supported by increased numbers of small Canadas in the Short Grass Prairie range comparable to the decline of the Tall Grass geese." This question of mixing could be best examined using DNA techniques because of the highly philopatric nature of Canada geese. Sections of DNA from birds across the breeding ranges of both TGP and SGP geese could be compared with DNA collected from birds in the wintering range. Results of this analysis would answer the question of mixing and allow for more prudent management of these species.

The case of the Canada geese is only one example of how genetic information can be used to study a management problem in waterfowl. Genetic markers can be useful in stocking programs, identification of gamefarm birds and in selection programs to improve stocks of waterfowl. The potential for developing practical applications for the use of genetic markers is great, and the technology is now available for new innovative approaches for solving complex management problems and providing new insights into the biology and conservation of waterfowl.

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Research Requirements for Shorebird Conservation

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Introduction

Effective shorebird conservation depends on the preservation of key areas of critically important habitat throughout the migration ranges of the birds, and on a sound understanding of the biology of the species concerned. Over the past 15 years, great strides have been made in our knowledge of the distribution of shorebirds, particularly on migration and wintering ranges, and of their migration patterns (e.g., Morrison 1984, Morrison and Ross 1989). Studies of various aspects of shorebird biology, including energy budgets, are providing important new insights into how their migration systems work (e.g., Ens et al. 1990, Castro et al. 1991). Many questions remain, however, concerning shorebird populations, ranging from the sizes of the populations themselves to various aspects of their biology which will affect the way in which they might be managed. This paper will briefly review some of the topics which future shorebird research should address.

Shorebird Research Requirements

Distribution

A number of large scale international and national projects in both North and South America have provided much information on shorebird distribution over the past 15 years (Morrison and Myers 1989). A key result of these studies, on both migration and wintering areas, is that large percentages of a species population often concentrate in a few key areas, making the population highly vulnerable to environmental perturbations; in many cases, there do not appear to be alternative areas in which the birds might turn if a key site were to be lost. Critically important areas provide food resources and roosting areas needed by the birds to accumulate the large energy reserves required to accomplish their long migratory flights, which are often over ecological barriers such as oceans or deserts. Migration is often timed to coincide with peak food resources, allowing limited flexibility in scheduling, and key areas in many cases are also targets for human activities, both industrial and recreational. In addition, the low reproductive output of shorebirds and the uncertainties of weather during the Arctic breeding season indicate that recovery from population declines is unlikely to be rapid (*see* Myers et al. 1987).

The picture thus emerged for shorebirds of populations, which although sometimes apparently numerous, were nonetheless vulnerable because of their high concentration into a limited number of key areas. The entire migration system depends on the healthy functioning of a chain of sites, and for conservation to be successful, it is clearly necessary to protect all the links in the chain, since elimination of one would disrupt the entire system. This result led to the proposal to create a Western Hemisphere Shorebird Reserve Network (WHSRN) which seeks to do just that—to bring protection to all the key sites throughout the migration ranges of various groups of shorebirds. The translation of the WHSRN concept from an idea to a practical reality has taken considerable persistence and effort, and the early success of the venture owes much to Pete Myers, then of the Philadelphia Academy of Natural Sciences and subsequently the National Audubon Society, and Pete McLain of the New Jersey Department of Fish and Game, and more recently to George Finney of the Canadian Wildlife Service, who is currently chairman of the WHSRN Council. In recent years, WHSRN has developed into a powerful and effective conservation tool and is being supported by a wide variety of governmental and non-governmental agencies on an international level.

Various gaps still exist in our knowledge, and these should be filled in the years to come. In South America, while coastal wintering areas are relatively well known, much less is known about the significance of interior wetlands to wintering and migrating shorebirds. Some coastal areas which were relatively unimportant as wintering grounds may turn out to be very important during migration, and survey coverage of various stretches of the coastline, on both Pacific and Atlantic sides of the continent, should be undertaken to determine key migration sites. Other areas requiring coverage include Mexico, Central America and the Caribbean. Coordination and publication of existing information on sites in the U.S.A. should be undertaken so that gaps in coverage may be identified and filled.

Very little information is available on the relative importance of different parts of the breeding ranges for many species, particularly in the Arctic. Here, the vast distances involved and the difficulty of obtaining estimates of breeding densities make the direct identification of key areas much more problematical than on migration and wintering areas. Few long-term studies have been carried out to determine the annual variability in breeding numbers or success, with the notable exception of work on the Truelove Lowland on Devon Island (Pattie 1990).

The use of remote sensing to investigate the distribution of breeding habitats and hence shorebird populations has great potential, though the application of the methodology to large areas is not always straightforward. Difficulties include the need for extensive ground truthing operations, especially where imagery from different dates and areas is being processed, and where different vegetational communities and terrain are found, as will certainly be the case over large areas. While the method may prove valuable in identifying important oases of habitat, considerable research will be needed to link the distribution of habitats or combinations of habitats quantitatively to use by particular species.

The effective design of reserve network systems depends on detailed knowledge of the migration patterns of individual species, so that appropriate sites are included in the network. Detailed studies of the red knot (*Calidris canutus*) (Morrison and Harrington 1991), sanderling (*Calidris alba*) (Myers et al. 1990) and semipalmated sandpiper (*Calidris pusilla*) (Harrington and Morrison 1979) have provided important insights into the migration routes and strategies of those species, but further research into the migration systems of other species needs to be undertaken.

Populations: Sizes and Life History Parameters

Knowledge of the population sizes of different shorebird species is another basic conservational requirement. However, estimates of the total population size exist for very few species of North American shorebirds.

It is difficult to estimate numbers occupying the breeding grounds, since details of habitat distribution and occupancy within the breeding range are often poorly known, though this has been attempted for populations of waders wintering in Europe and breeding in Greenland and northern Canada by Meltofte (1985).

Counts of concentrations occurring at migration areas may provide minimum figures, though it is difficult to obtain coordinated information on specific dates over wide areas, and uncertainties may exist as to whether part of the population may overfly a given area. In addition, estimation of total numbers passing through an area will require some knowledge of the turnover rate at the site. Hicklin (1987) estimated the numbers of shorebirds passing through the Bay of Fundy in eastern Canada using counts and an estimated turnover time of 15 days. Turnover rates may vary considerably between different areas, and Butler et al. (1987) estimated that western sandpipers staged for only two to three days in the area of the Fraser River delta in British Columbia during autumn migration. Further research is needed to investigate how widespread such differences may be and how turnover times may vary between species. This is of considerable practical importance when assessing the numbers of shorebirds using a particular site.

Counts made on the ''wintering'' grounds, when the birds are relatively immobile, provide another opportunity of assessing population numbers. This approach has worked well on European estuaries, where the relatively restricted area to be covered and large number of potential counters has made mid-winter estimates of many species possible. In the New World, the approach is more problematical, since wintering ranges of shorebirds extend over enormous distances, from Canada and the U.S.A. southwards to the southern tip of South America, and many areas are very remote, requiring coverage by aerial surveys. The only continental estimates for wintering populations are those obtained during the Canadian Wildlife Service South American Shorebird Atlas Project, whose objective was to determine the major wintering areas used by Nearctic shorebirds on the coastline of South America (Morrison and Ross 1989). Species totals from these surveys are likely to be minimal, since flights over such enormous and remote regions precluded coverage of all areas during ideal tidal or weather conditions or any realistic ground truthing. Totals for individual species were comparable to those obtained by other methods: for instance, the South American total for red knot of 76,000 compares with estimates of 100,000 by Harrington et al. (1988) derived from banding studies. The 2.1 million small sandpipers (mostly semipalmated sandpipers) seen on the north coast of South America is consistent with estimates of some 2–5 million from banding studies in Suriname by Spaans (1984).

Population Trends

An urgent current requirement in shorebird research is an authoritative and updated assessment of population trends for different species. The only long-term data sets of shorebird counts from migration areas are those of the International and Maritimes Shorebird Survey (ISS and MSS, respectively) operations conducted in eastern U.S.

and Canada by the Manomet Bird Observatory, Massachusetts, and Canadian Wildlife Service, respectively, both of which have operated since 1974. Analysis of the ISS data up to 1982–83 by Howe et al. (1989) indicated that 3 of the 12 species analyzed had declined significantly, namely the sanderling, short-billed dowitcher (*Limnodromus griseus*) and whimbrel (*Numenius phaeopus*). Six of the remaining nine species also showed declines, which, although not statistically significant, indicated mean annual percentage changes of 3–12 percent and cumulative percentage changes over the period 1972–1983 of up to 75 percent (for the red knot).

Preliminary analysis of recent aerial survey data from James Bay and Hudson Bay indicates that numbers of red knots, Hudsonian godwits (*Limosa haemastica*) and small sandpipers may have declined compared with counts made during surveys carried out at similar time periods in the late 1970s (Morrison and Ross unpublished data), and numbers have declined at several sites along the St. Lawrence River and in the Gulf of St. Lawrence, where habitat alteration and losses have occurred (Morrison et al. 1991).

In view of these indications of decline, it is particularly important that data be drawn together from as many sources as possible to assess the current status of shorebird populations. Updating and (re)analysis of both ISS and MSS data are needed not only to assess current trends in shorebird populations but to assist in the design of the most effective future monitoring scheme.

It is not known to what extent shorebird populations may fluctuate "naturally" over a mid- to long-term period, given the variations in weather and nesting success that occur on the breeding grounds. Some modelling of possible fluctuations might be valuable for providing a comparison with estimates of population changes actually occurring. There is little historical data available in North America (or elsewhere) to work with, and few or no direct long-term studies have been made of annual variations in breeding success in Arctic environments. Boyd (1991) has attempted to relate fluctuations in the European-wintering population of knots to weather conditions on their Canadian High Arctic breeding grounds and to their effective recruitment, as measured by numbers of juveniles caught during banding on the wintering grounds. Further research in this direction may provide valuable insights into the relative contributions to annual mortality of "naturally occurring" environmental factors, such as weather, and man-induced changes, including alterations to habitats and climatic change.

Estimates of Annual Survival/Mortality

Once shorebirds have survived their first year, they are relatively long lived, with annual survival rates of around 85 percent for medium-sized species (e.g., Evans and Pienkowski 1984). Further refinement of estimates for particular species are needed, and a better assessment of the extent to which annual survival rates may vary between years.

A more important aspect of the study of annual mortality is the investigation of where survival bottlenecks may occur during the year. Recent work (e.g., on sanderlings *see* Myers 1980, Castro et al. 1991) has indicated, for instance, that long-distance migratory flights do not normally pose a special risk for shorebirds, provided of course that they are able to accumulate the energetic reserves required to complete the flight and that they do not meet catastrophic weather conditions en route. Predation appears to be important in some areas for some species (e.g., in California [Page and Whitacre 1975]) but negligible in other areas (e.g., Peru, Panama and New Jersey [Castro et al. 1991]).

Energetic and Ecophysiological Studies

The study of energetic budgets of shorebirds during various phases of the annual cycle is proving very productive in determining how shorebirds cope with meeting the energetic and nutritional demands both of daily living and of more energy costly activities such as migration, and in identifying where and under what circumstances populations fall under stress in meeting these demands. Castro et al. (1991) studied four populations of sanderlings, wintering in New Jersey, Texas, Panama and Peru. Despite the very different distances each population had to migrate from Arctic breeding grounds and the very different climates involved, birds at three of the sites (New Jersey, Panama and Peru) appeared to be under little stress, in that they maintained good body condition (with different levels of reserves related to the climate), spent about 50 percent of their time feeding, indulged in little competitive or aggressive behaviour and appeared to suffer remarkably little predation. In contrast, birds at the fourth site (Texas), despite living in a relatively benign climate, were clearly much more stressed, in that they were in poorer physical condition with lower body reserves, had to spend up to 84 percent of the day feeding, and showed territorial behaviour. No information was available on annual survivorship at the different sites. Contrary to currently accepted ideas concerning the evolution of bird migration, Castro et al. (1991) suggested that the birds did not necessarily gain access to better living conditions by migrating further south (although birds in Peru did spend less time feeding than those in New Jersey): they were able to maintain good physiological condition at sites where daily (and annual) energy expenditures were very different. The highest densities of birds occurred at the sites in Peru and Panama, indicating that food resources there were probably more abundant. The sites from which the highest amounts of energy were extracted by the birds (daily energy expenditure multiplied by the bird density, to give an estimate of Kj/km/day), however, were Peru first and New Jersey second, implying that although New Jersey might be colder and more demanding in terms of energy acquisition, the food resources there were able to provide the required energy, and the birds in fact extracted more energy per km of beach than in Panama. This approach might give some insight into the potential carrying capacity of a site, though the question of assessing the *available* prey, as opposed to the density of prey present, presents perennial difficulties.

Studies on northern Ellesmere Island have recently shown that knots and turnstones bring substantial reserves of both fat and protein to the breeding grounds, and that such reserves are important for both early season survival and breeding (Morrison and Davidson 1990). Further studies of the energetic budgets of birds on the breeding grounds should show whether climatic factors limit shorebird distribution.

More research into the effective assessment of available prey in different key seasonal areas would be most valuable, since we have little quantitative information on the food stocks at the major shorebird stopover and wintering areas. Many studies have shown that shorebirds tend to concentrate locally in areas where densities of their preferred foods are highest, yet hardly any comparative studies have been made to determine whether this factor drives shorebird distribution over large geographical areas. Assessment of potential prey at little used areas could also provide some direct data for assessing to what extent such areas might be used by shorebirds if a key area were lost. If such areas did indeed turn out to contain little usable prey, arguments for conservation would be considerably strengthened.

Little is known about long-term variations in prey density at individual sites and how this may affect shorebird migration and/or distribution. Prairie lakes provide an example of sites that vary widely in suitability for shorebirds depending on the water levels and conditions in a given year. Another example is provided by the almost complete disappearance of red-necked phalaropes (*Phalaropus lobatus*) from the Bay of Fundy area in recent years. In the late 1970s, up to half a million phalaropes were regularly reported off Deer Island in Passamaquoddy Bay (Morrison et al. 1991), whereas current surveys have indicated that there are currently almost no phalaropes in the same area (P. W. Hicklin personal communication). The reasons for this shift have not yet been clearly identified, although there are indications that oceanographic conditions (involving temperature) have changed, and that the previously abundant food stocks are no longer present in the area. These situations emphasize the need for long-term studies to understand how altering food resource patterns are likely to affect shorebirds—and for continued monitoring to detect the changes as they occur. They also emphasize the need for flexibility in responding to such changes by adding (or even deleting) reserve network sites, to track current and long-term shorebird use.

Genetic Studies

Studies of shorebird genetic material may prove useful in identifying particular breeding populations on migration and wintering areas and may reveal the extent to which population mixing takes place. Some recent studies (Baker 1991) have suggested that little genetic differentiation has taken place in some species of shorebirds breeding in northern Canada (knots and purple sandpipers [*Calidris maritima*]), suggesting relatively recent evolution of the subpopulations; whether such results may have implications concerning the ability of species to survive environmental stress is not known.

Parasite Studies

Parasite loads may be important in affecting the health of shorebird populations, though little is currently known about this subject. It appears that different species of nematode worms may be acquired by shorebirds in particular geographical areas, and this may provide another method of tracing migration routes of shorebirds (Wong and Anderson 1987).

Toxic Chemicals

Relatively little work has been carried out on the presence of toxic substances in shorebirds (Noble 1991). Some shorebirds may be exposed to contamination by organochlorines in various parts of their wintering ranges, including California, Texas, New Mexico and Arizona, as well as in Ecuador and Peru in South America; levels in Suriname were relatively low (Fyfe et al. 1990). Selenium may be a potential hazard in some agricultural areas. Shorebirds collected at the end of the wintering period are often more contaminated than those collected in autumn though no information is available on levels remaining in birds by the time they reach the breeding grounds. Accumulation of lipophylic substances during deposition of large fat reserves at stopover areas could be dangerous, since much of the toxic load would be released during metabolism of the fat on the subsequent flight. A monitoring program designed to assess the situation at important stopover areas, which are already or proposed WHSRN sites, would provide further information with which the need for further studies could be assessed.

Threats to Shorebird Habitats

Although it is well-known that wetlands have decreased extensively in the Americas (Senner and Howe 1984), little coordinated information has been produced to assess specific threats at key shorebird areas. Research to determine the extent and seriousness of environmental threats at key areas—in effect, an atlas of threats to key shorebird areas—would provide a valuable summary of current knowledge and highlight how urgent conservational action may be.

Discussion

Some of the most significant advances in shorebird conservation have resulted from large-scale international programs investigating migration or distribution over wide geographical ranges. Such projects provide the broad perspective essential for the design of effective conservation measures for such highly migratory birds. Future research will also benefit from a broad geographical approach, though detailed studies at particular locations will always be required to obtain adequate information on the biology of the species concerned. The combination of several approaches, such as that of Castro et al. (1991), which included investigations of energy budgets, physiological condition, time budgets, and knowledge of the distribution and migration of the species concerned, can be highly productive in revealing new aspects of shorebird biology that are relevant to conservation.

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International Approach to the Conservation of a Migratory Caribou Herd

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Introduction

Large migratory caribou (*Rangifer tarandus*) herds indigenous to northern latitudes roam over vast areas, with seasonal ranges often separated by hundreds of kilometers. Even within the seasonal ranges, large herds move continuously in response to changes in food availability and quality, insect harassment, predators or snow conditions. While range loss or fragmentation due to human encroachment may cause neither local nor regional extinction of caribou, most biologists agree that free access to vast areas of range is necessary for the continued existence of large migratory herds.

Migratory activity, when confined within a political boundary, such as with the Western Arctic caribou herd (population = 340,000) in Alaska, poses little difficulty in management. In the event that migrations transect adjoining state, provincial or territorial boundaries, such as with the Beverly and Kaminuriak caribou herds in Canada, a cooperative management effort involving the federal and local governments, as well as the traditional user groups, is required. This was admirably demonstrated by the formation of the Beverly-Kaminuriak Caribou Management Board in 1982. But when migration patterns involve the crossing of international borders, the jurisdictional authority for management can become even more entangled in traditional, philosophical and political differences. The Porcupine Caribou Herd (PCH) of northwestern Canada and northeastern Alaska (Figure 1) is an example of this management dilemma. How this management problem is being addressed by the formation and implementation of international management agreements is the subject of this paper.

Annual Migratory Pattern

The PCH is 1 of about 10 caribou herds in North America that form spectacularly large aggregations and migrate over vast areas seasonally. Smaller herds also exhibit migratory patterns within correspondingly smaller geographic areas. Extensive geographical movement patterns are most often associated with large population size (usually in excess of 100,000 animals).

The PCH winters primarily in mountain and taiga habitats south of the Arctic divide in Alaska, the Yukon and the Northwest Territories. Although some wintering areas and migration routes are used regularly enough that traditional hunting villages

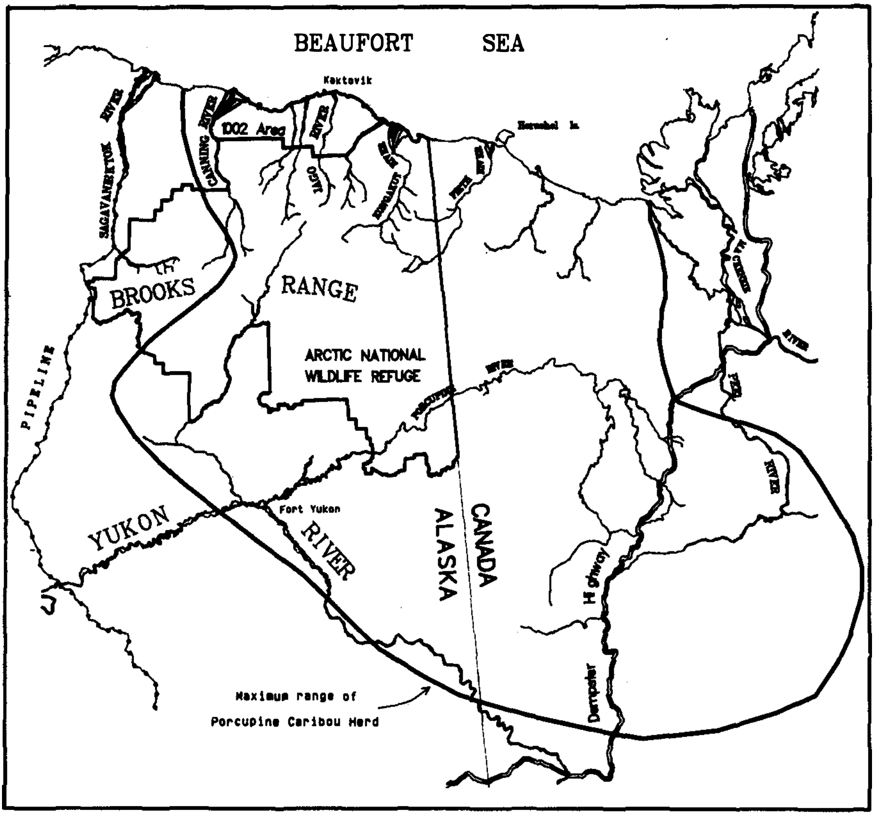

Figure 1. Range of Porcupine Caribou Herd in northwest Canada and northeast Alaska.

have successfully persisted for decades, if not thousands of years, individual caribou do not show strong fidelity to specific winter sites. Thus distribution of animals varies greatly from year to year, with some locations rarely visited and even the most traditional areas abandoned in some years. Even the most successful and persistent subsistence villages occasionally faced starvation years.

Fall migrations onto the winter range tend to follow fairly broad and diffuse fronts. Although there is some tendency for the PCH to follow ridge systems and higher ground in the fall, movements are not yet hindered by snow cover and the caribou apparently can select any route to wintering habitat. In contrast, spring movements from the winter range are more often confined to windswept ridge systems that provide paths of least resistance through otherwise impassable, deep snow. However, as spring season progresses and the urge for pregnant cows to reach their calving areas increases, tens of thousands of caribou can and do break trails through all but the deepest snow.

The calving grounds are the only part of the range used consistently year after year. In fact, fidelity to specific calving areas is what defines caribou herds as separate populations. The calving grounds of the PCH lie on the Arctic coastal plain of northeast Alaska and the Yukon, but by far the most heavily used portion of the calving grounds is in Alaska (Figure 2) in the Arctic National Wildlife Refuge in what is know as the 1002 Area. Only deep snow conditions, due to late spring thaws, seem to prevent the PCH from reaching this area, and that has only happened twice in the past 19 years. Commonly, one-half to three-quarters of the calves are born in a 2,500 km^2 area that comprises only about 1 percent of the entire herd range and about one-fourth of the potential calving grounds. This traditional high-density calving area appears to offer a combination of environmental factors that enhances survival and productivity: (1) the forage necessary to meet the immediate nutritional needs of maternal cows; and (2) added potential for predator avoidance.

Shortly after calving, most, and often all, of the remaining herd joins the cows and calves on the coastal plain. In late June and early July, when mosquitoes harass the caribou, small scattered groups congregate into larger and larger aggregations. In the 1002 Area, aggregations of up to 100,000 caribou occur nearly every year at this time. Subsequent to aggregating, the PCH migrate to the east and south toward their fall and wintering range.

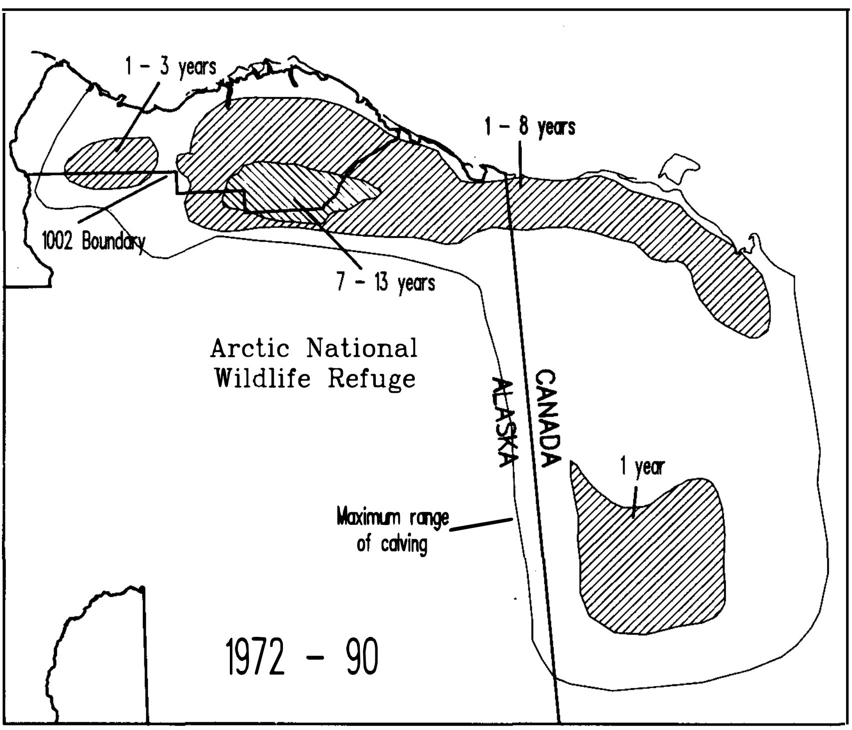

Figure 2. Composite of Porcupine Caribou Herd calving areas from 1972–1990.

Jurisdictional Conflict

Eighteen native villages in two nations (involving one state and two territories) depend on the PCH as their primary food source. In addition, a subsistence lifestyle based on caribou has shaped the cultural heritage of these people. These facts, in conjunction with the natural phenomenon of the post-calving aggregations, have long focused international attention on the PCH. Add to this scenario the recent finding that the 1002 calving area is encompassed by the most promising onshore petroleum prospect in North America, and the scene is set for a substantial management and conservation challenge.

Not only do the caribou freely cross an international border, thereby invoking two national jurisdictions, but within each country, no single agency has sole management responsibility of the animals and their habitat. In fact, the wildlife agencies involved seldom have more than an advisory role in habitat and land use decisions. In the case of the PCH, at least 10 different units of government (Table 1) share some management authority for the caribou and/or their habitat. As development proceeds in the north, more and more people will compete for the caribou resource, while at the same time other people and agencies will pursue activities that will conflict with caribou use of their traditional habitat.

Although all of the managing agencies may profess the same goal regarding the welfare of the caribou, they also are subject to the specific agendas of local, state (territory) or federal governments. In Alaska, management of the harvest is primarily the purview of the Alaska Department of Fish and Game (ADF&G), while management of the caribou habitat is the jurisdiction of the Arctic National Wildlife Refuge (ANWR), which is within the U.S. Fish and Wildlife Service (USFWS) and, therefore, subject to the policies of the Department of the interior. In Canada, the

Table 1. Agencies concerned with the management of the Porcupine Caribou herd.

United States
U.S. Fish and Wildlife Service
Arctic National Wildlife Refuge
Yukon Flats National Wildlife Refuge
Alaska
Alaska Department of Fish and Game
North Slope Bourough
Canada
Canadian Wildlife Service
Northern Yukon National Park
Department of Northern Indian Affairs
Porcupine Caribou Management Board
Yukon Territory
Department of Renewable Resources
Northwest Territories
N. W. Wildlife Services

use of the PCH is independently managed by the governments of the Yukon and Northwest Territory. Land management primarily is dictated by the federal Department of Environment (Northern Yukon National Park) and the federal Department of Indian Affairs and Northern Development.

In addition to the managing agencies, politically influential, local user groups and governments exert pressure on the management of the PCH. Native groups in Canada and the United States—such as the Council for Yukon Indians, Inuvialuit Game Council, Dene Nation and Metis Association, Kaktovik Inupiat Corporation, Arctic Slope Regional Corporation, Doyon Regional Corporation, Tanana Chiefs Conference, and the Gwich'in Nation, which represent the majority of the populace in this northern Arctic region—demand involvement in management decisions. Sportsmen and environmental organizations also vie at the local and national levels to influence herd or land-management policy.

The concerns and policy directions from the various agencies have not always been compatible, which is not surprising given the transient nature of the resource and the varying influences regarding the use of the caribou resource. Conflicts will naturally arise when one agency's policy, in fact or appearance, impacts the resource availability to the constituents of another agency. An example of this potential concern with the PCH has been demonstrated at the federal level. the U.S. Department of Interior has determined that the effects of developing the oil and gas resources of the 1002 Area would have minimal impact on the PCH, therefore, it has recommended Congress authorize leasing. The Canadian government, on the other hand, felt that development would have a more dramatic affect on the welfare of the herd so, therefore, created the Northern Yukon National Park to protect a portion of the calving habitat of the PCH. Among Alaskan native groups that have cultural ties to the PCH there are extreme differences in management philosophy. Although the native organizations all wish to retain their cultural subsistence rights to the PCH, North Slope natives, who will benefit directly from development, want development to proceed, albeit in an environmentally responsible fashion. The interior native groups that will not benefit directly from the oil development are opposed to any disturbance of the PCH's habitat and would like to see the 1002 Area designated as wilderness. The question of subsistence use versus sport harvest is another thorny problem that faces both federal and local agencies, since both user groups are affected by the management program adopted.

Interjurisdictional Agreements

In an attempt to reduce conflict and to provide a comprehensive strategy for the management of the PCH, two federal agreements have been instituted: (1) the in-Canada Porcupine Caribou Management Agreement (1985); and (2) the international Porcupine Caribou Conservation Agreement (1987). Both agreements provided for the establishment of advisory boards to make recommendations to the appropriate government agencies regarding management and use of the PCH and the preservation or use of the herd's habitat. The in-Canada Agreement established the Porcupine Caribou Management Board (PCMB), which is comprised of representatives from the governments of Canada, Yukon, and Northwest Territories and from three native councils. The primary charge to the PCMB was to facilitate communication among the users and managers within Canada, concerning the management of the PCH.

Additional responsibilities included reviewing scientific information, encouraging native participation and making recommendations on herd management. Since its inception, the PCMB has developed an interim management plan that incorporates goals to address the welfare of the caribou herd and the needs of the people. This effort is seen as the precursor to an international plan to be developed by the International Porcupine Caribou Board (IPCB) for the entire herd throughout its range.

Established by the International Porcupine Caribou Agreement, the IPCB is comprised of four representatives from each country appointed by the respective federal governments. Delegation members from each country include representatives from the federal, state (territory) and native organizations. The responsibilities of the IPCB, which meets biennially, are stated in Section 4 of the Agreement to ". . . make recommendations and provide advice on those aspects of the conservation of the Porcupine Caribou Herd and its habitat that require international coordination. . . ." The aspects that are identified for the IPCB to advise on include: (1) sharing of information; (2) conservation of the PCH and its habitat; (3) cooperative conservation planning; (4) harvest levels and limitations; and (5) identification of sensitive habitats.

To facilitate compilation of technical information, the IPCB has obtained the assistance of the Porcupine Caribou Technical Committee (PCTC), which consists of one caribou biologist from each of the five management agencies represented on the IPCB. At the request of the IPCB, the management agencies have agreed to maintain the PCTC as a distinct entity and make it available for technical support and advice to the IPCB, as well as to the agencies. The PCTC provides two functions: (1) an annual status report on the PCH; and (2) coordination and standardization of scientific fieldwork on the PCH and its habitats. Prior to the formalization of this committee, the biologists from the different wildlife agencies had been working cooperatively in obtaining data on the ecology of the PCH. These cooperative efforts were initiated by field biologists who recognized that a thorough understanding of the ecology of this migratory herd was a management necessity and irrespective of political boundaries.

Conclusion

The international Porcupine Caribou Conservation Agreement, established a mechanism to address the concerns regarding an important international resource. Although this Agreement does not have the enforcement authority found in the Migratory Bird Treaty Act of 1961, it is attempting to address some of the same types of concerns. Even with some fundamental differences in philosophy regarding impacts of potential development within the range of the PCH, Canada and the U.S. have established an official conduit for communication, education, management implementation and the exchange of scientific information. By adopting a management plan based on that devised by the PCMB or implementing an independent plan which addresses both the caribou and human needs, the IPCB will have demonstrated that, through constructive interaction, and important environmental resource can be managed, shared and preserved.

Acknowledgments

The current research effort on the PCH is cooperative among the U.S., Canadian, state, and territory management and research agencies charged with the responsibility for the caribou and their habitat. The research is funded in some measure by all of the cooperating agencies. We would like to thank G. Elison, B. Griffith, and N. Walsh for the critical review and constructive comments on this manuscript.

Management of Shared Populations of Polar Bears

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Introduction

Polar bears are distributed in relatively discrete subpopulations throughout the circumpolar Arctic. Because they maintain a high degree of seasonal fidelity to particular areas for feeding, maternity denning, or summer sanctuaries and because almost all their hunting is done from the surface of the sea ice (Stirling 1974, Lowry et al. 1987), polar bears may move extensively between seasons. The extent to which polar bears in different subpopulations move between seasons depends on regional patterns of freeze-up, winter movement, and break-up of the annual ice (e.g., Stirling et al. 1984, Schweinsburg et al. 1982, Garner et al. 1990). As such, polar bears are best considered as facultative, rather than obligatory, migrants. There are several subpopulations of polar bears that are shared between countries. Similarly, within Canada, the majority of subpopulations are shared between Provincial and Territorial jurisdictions. The need to manage Canadian subpopulations cooperatively is comparable to the need to manage experienced on an international scale.

The Motivation for Cooperation in Polar Bear Management

The stimulus for international cooperation in research and management of polar bears was provided by world-wide concern in the early 1960s that they were being overharvested and might become endangered. After the first international meeting on the conservation of polar bears, held in Fairbanks, Alaska in 1965, the International Union for Conservation of Nature and Natural Resources (IUCN) established a Polar Bear Specialist Group under the auspices of the Survival Service Commission (Stirling 1986). The group has participants from all five nations with polar bears (Canada, Denmark [Greenland], Norway [for Svalbard], USA, and USSR) and has met every two to four years since 1968. Among other things, these meeting accomplished the signing of the International Agreement on the Conservation of Polar Bears, in Oslo, Norway in November 1973.

From a conservation point of view, the most profound part of the Agreement is probably Article II which states, "Each Contracting Party shall take appropriate action *to protect the ecosystems of which polar bears are a part* (author emphasis), with special attention to habitat components such as denning and feeding sites and migration patterns, and shall manage polar bear populations in accordance with sound conservation practices based on the best scientific data." From this statement, it is clear that the objective is to prevent polar bears from becoming endangered because of excessive hunting or degradation of their habitat by man's activities. Article VII goes on to state ". . . They (Contracting Parties) shall . . . consult with other Parties on the management of migrating polar bear populations. . . ."

Issues Encountered in the Management of Shared Populations

From the time of the initial polar bear meeting in Fairbanks in 1965, to the signing of the International Agreement in 1973, the perception of the problem was fairly straightforward: polar bears were thought to be threatened because of overharvesting and additional protection was the solution. (The Soviet Union had already banned the killing of polar bears in 1956.) In 1968, interim quotas, based on harvest records, were established in the Northwest Territories, where most polar bears are killed in Canada. In the United States, the Marine Mammal Protection Act (MMPA) of 1972 prohibited the killing of all marine mammals, including polar bears, except by native people for subsistence purposes. Norway introduced new regulations in 1970 which prohibited the use of set-guns at Svalbard and summer trophy hunting from ships. An annual quota was introduced, which gradually reduced the harvest until all polar bear hunting in Svalbard was banned in 1973. Additional administrative initiatives followed in all countries and there was a large increase in research on subpopulations and ecology, the details of which are provided in the Proceedings of the IUCN Polar Bear Specialists Group (available from IUCN Publications, CH-1,196, Gland, Switzerland).

Since the signing of the International Agreement on the Conservation of Polar Bears, and largely because of the research encouraged by it, our knowledge of the biology of polar bears and the status of many subpopulations has increased greatly. It seems that the numbers of polar bears in most areas have increased (e.g., Stirling et al. 1977, Amstrup et al. 1986, Larsen 1986) although, concerns persist about a few subpopulations. While the initial results of controlling the harvest have been positive, a significant amount of cooperation between jurisdictions is still required to deal with harvesting completely and with new developments affecting polar bears.

Allocation of Harvest

Until relatively recently, hunters taking bears from shared populations were usually limited either by the availability of bears or, in some cases, by quotas set independently by the jurisdiction in which they live. Because of this, diametrically opposed management practices could be applied by different jurisdictions to the same subpopulation, regardless of the potential consequences. For example, prior to 1972, Alaskan-based hunters harvested polar bears from the Chukchi Sea subpopulation under a variety of quota systems while the same subpopulation was totally protected in the Soviet Union.

After 1972, an even more anomalous circumstance persisted in the southern Beaufort Sea where a subpopulation of polar bears is shared by Canada and Alaska. Beginning in 1968, strictly enforced quotas were set for the Canadian Inuit settlements. Meanwhile, in Alaska, under the MMPA, there was neither a limit to the number of bears that could be killed by natives for subsistence, nor any protection for females with cubs or bears in dens. Thus, it would be perfectly legal to overharvest bears in Alaska and the management authority could not take any action until after the subpopulation had been declared depleted. Although the kill in Canada was controlled, the recorded harvest in Alaska fluctuated widely and could not legally be regulated, leaving the polar bear population vulnerable to overharvest. In this case, the users themselves took the initiative to resolve the problem by negotiating their own management agreement, based on the most current scientific information available (Nageak and Brower 1991). Admittedly, the Agreement between the Inupiat of Alaska and the Inuvialuit of Canada has not yet stood the test of time but, if successful, it will be a significant model for the resolution of similar problems with shared populations.

Within Canada, a particularly complicated situation prevails in the area of James Bay, Hudson Bay, Foxe Basin, Hudson Strait and the Labrador Sea. There are at least three subpopulations of polar bears being harvested by Inuk and Indian hunters from five different Provincial and Territorial jurisdictions. Even though 250–300 polar bears are harvested from this area annually, our collective knowledge of population size and distribution is sparse and fairly localized, both in geography and subject matter (Stirling and Ramsay 1986). Furthermore, the application of management practices is quite variable between jurisdictions, although all comply generally with the intent of the International Agreement. It appears that conservation initiatives may need to be taken before there is enough new research information to guide the development of management plans. As was the case in the southern Beaufort Sea, it seems likely that resolution of this problem will require the initiative of the users because quotas and harvest allocation will be involved. To be effective, decisions on polar bear conservation need to have the active participation of the users (both consumptive and nonconsumptive) who will be affected. For the most part, seeking compliance solely through enforcement by the responsible government agencies will not be enough. Conversely, decisions made by the users themselves will likely require little enforcement (Stirling 1991).

Exploitation of Nonrenewable Resources

Since the early to mid-1970s, there has been a marked increase in exploration for, and production of, hydrocarbons from the continental shelf throughout the Arctic. The potential for detrimental effects on polar bears has been summarized by several authors (e.g., Øritsland et al. 1981, Stirling 1990). It is fundamental that any negative effects incurred not be additive to the sustainable harvest of a subpopulation. If industry-related mortalities are few, they can probably be subtracted from the quota allocation of the jurisdiction in which the damage occurs. If loss of polar bears or damage to habitat, or both, are substantial, it could take decades for a subpopulation to recover. Depletion of a subpopulation as a result of human activities might necessitate closing the polar bear harvest until it recovered and paying compensation to native people who depend on that resource as part of their economy.

Within Canada, negotiations are proceeding on industrial liability for damage to polar bear subpopulations in the Beaufort Sea. There is also an international component to this issue because the polar bear subpopulation of the southern Beaufort Sea is shared between Canada and Alaska. In Alaska, oil leases are held on both state and federal lands so that drilling permits are written by two independent entities. There needs to be consistency in the stipulations relative to polar bears set by different agencies in Alaska and between Alaska and Canada. Similar consistency will be required in other areas where subpopulations of polar bears are shared and offshore drilling for hydrocarbons is being considered.

Problem Bears

Polar bears are dangerous animals and, occasionally, they threaten humans or their property. In this situation, it is often possible to simply remove the bear from the situation and release it unharmed but, in some circumstances, killing it is unavoidable. In subpopulations for which there is a quota, problem bears should be subtracted from the allocation to the jurisdiction in which the bear was taken to ensure an overharvest does not take place. The possibility of problem bear mortalities needs to be incorporated into the development of agreements on the management of shared populations.

Tourism

One of the most interesting shared subpopulations of polar bears in the world, with respect to the diversity of priorities to be considered in its management, is the one that resides along the coast of Manitoba and the Northwest Territories in western Hudson Bay. The maternity denning area where the cubs are produced is in Manitoba while the bears hunt seals on the sea ice in the Northwest Territories. During the summer, all the annual ice on the bay melts, forcing the bears onto shore, mainly on the Manitoba coast, until freeze-up the following autumn. As a result, polar bears are abundant near the town of Churchill. Beginning in the early 1980s, local entrepreneurs built special vehicles to take tourists out to see wild polar bears. There are still no accurate estimates of the economic value of polar bear tours to the Province of Manitoba but conservative guesses exceed a million dollars per fall.

Because of the proximity of so many polar bears near Churchill in the fall, problem bears near the town are a constant danger. However legitimate it may be to kill a bear that is threatening life or property, it is distasteful to the conservation community at large and is particularly unpopular with tourists visiting the area. It may also reduce the pool of animals available for viewing by tourists at some future date. Thus, to minimize the killing of problem bears, the Manitoba government built a holding facility where bears that venture too close to town can be detained safely and then be released after freeze-up. For up to three months, during the bear season in the fall, Conservation Officers maintain a 24-hour patrol to protect the town and prevent bears from being killed.

When freeze-up begins in the late fall, the bears begin to move north and east onto the new ice in search of seals and some pass near coastal Inuit settlements in the Northwest Territories. To the Inuit, hunting polar bears is an important part of their culture and economy. They earn part of their cash income by selling the hides of bears they kill themselves as well as by guiding nonresident hunters to hunt some of their quota allocation.

Consequently, for this shared subpopulation, the goal of one jurisdiction is to kill its full share of the maximum sustainable harvest, while the priority of the other is to have the greatest number of live bears available for viewing by tourists. One potential conflict in jurisdictional priorities is quite specific. Adult male bears are particularly sought after by Inuk hunters because their larger hides have a higher market value, and sport hunters desire them for trophies. In the Northwest Territories, hunters are encouraged to hunt males rather than females because polar bear populations can only sustain a very low rate of harvest of adult females (Taylor et al. 1987). At the same time, however, tourists in Manitoba particularly want to see and photograph large males. Overall, the economic value of live bears for viewing greatly exceeds that of bears killed for hides or as trophies. In a world where killing animals is becoming progressively less popular and more people seek to view wild polar bears, it seems likely that decisions about management priorities will become more difficult.

Conclusions

For over 25 years, there has been a consensus that subpopulations of polar bears that are shared internationally (and subpopulations shared between different national jurisdictions) should be managed cooperatively. So far, however, a formal management agreement has been drawn up for only one subpopulation, that in the Southern Beaufort Sea. Within Canada, the Federal-Provincial Administrative Committee for Polar Bear Research and Management agreed to guidelines for dividing the quota for shared subpopulations of polar bears in 1987, although they have not yet been applied. This probably indicates the difficulty of making pragmatic decisions on the basis of limited scientific information while trying to balance the political pressures of a wide range of regional and national priorities. No one has yet tried to weight and incorporate factors such as bears in a shared population spending disproportionate amounts of time in different jurisdictions, the location of feeding or maternity denning areas, or the relative importance of consumptive versus nonconsumptive uses.

To a large degree, the polar bear has been a conservation success story but we cannot afford to be complacent. Lyster (1985) noted that the Polar Bear Agreement ". . . has proved very successful as a legal conservation instrument . . . and . . . has undoubtedly contributed to the establishment of protected areas for bears, to restrictions on hunting, and to the substantial amount of scientific research that has been carried out in recent years." He also notes the principle weaknesses of the Agreement: the terms are not enforceable in any country and there is no infrastructure to oversee compliance. While a great deal has been accomplished in the management of shared subpopulations of polar bears, it is clear that much of the critical work is yet to be done.

Acknowledgments

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Closing Remarks

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The papers in this session have been of extraordinary diversity, in topic, approach, information and interpretation. Rather than attempt to encompass their variability, I propose to reflect on a few themes that have also emerged from other sessions. Partnerships are in fashion. This morning, we heard about recent progress in co-management of northern wildlife resources by indigenous peoples and government agencies—a crucial and promising development. This afternoon, we began with a progress report on the implementation of the North American Waterfowl Management Plan (NAWMP)—the most ambitious multilateral attempt yet made to conserve essential wetlands. Though the plan was signed in 1986, it has only recently begun to be fully funded, so that it is too soon to know how well it may work. The NAWMP exhibit in the foyer includes a graph of rising numbers of mallards and pintails in the next decade that is as implausible a projection as I have seen since the publication in the late 1940s of Kip Farrington's book *The Ducks Came Back*. Waterfowl do not obey orders, however well-intentioned.

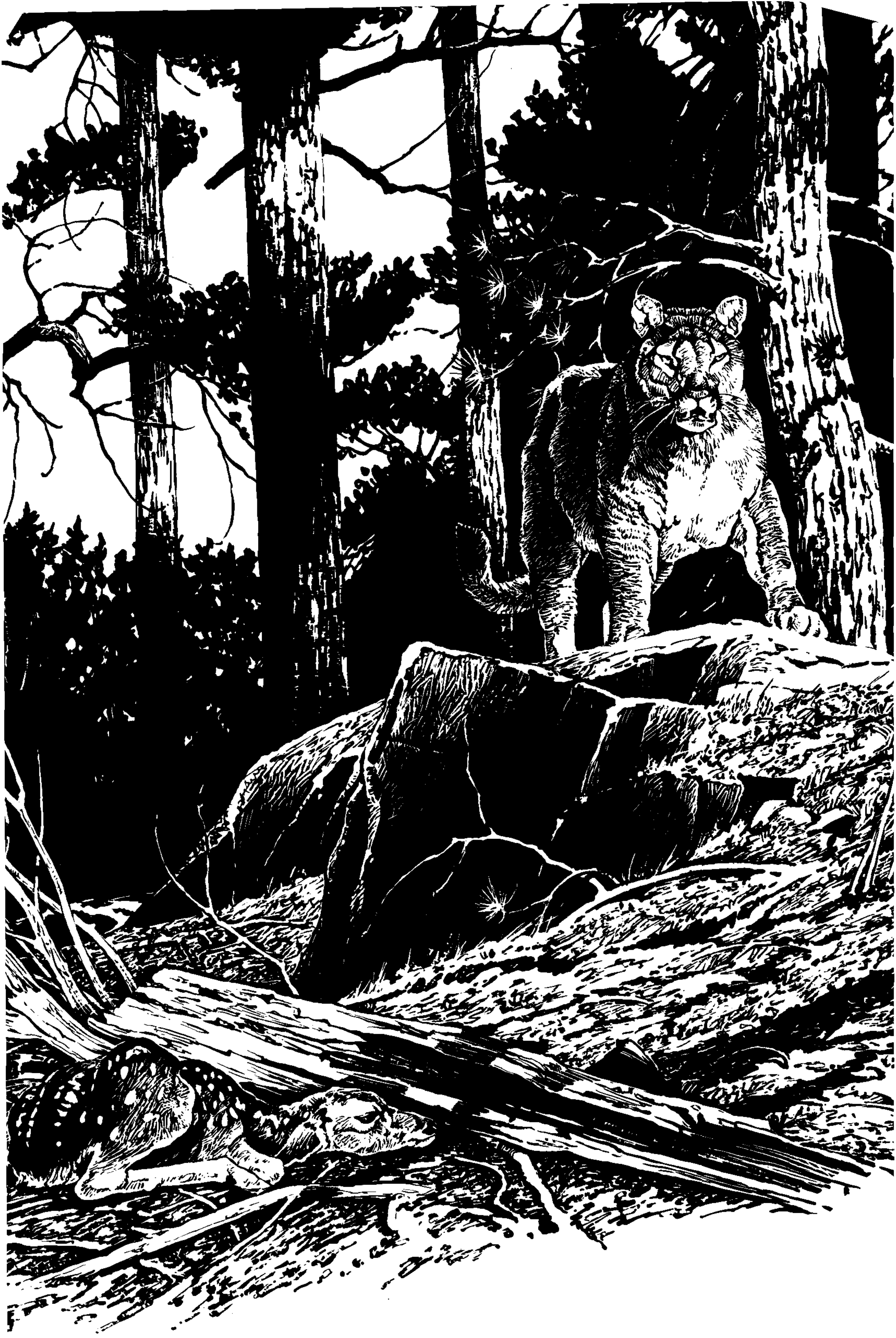
As the conservation movement has grown, we have seen increasing emphasis put on the necessity of bringing ecology and economics together. I believe that it is also necessary to pay much more attention to ethics in our attempts to limit human damage to the environment. We should attempt to develop a normative ecology, following the lead of normative economics, which has established itself over the last 25 years as a helpful way of addressing some important issues neglected by earlier orthodoxies.

Who might create this new subject is not obvious. Most wildlife scientists are happy to concentrate on accumulating information and increasing understanding within their own discipline. That is not enough. The classical scholar A. E. Housman wrote ("Preface" to Manilius I [1903]) that "the faintest of all human passions is the love of truth." It was his intense love of truth that made him so formidable a scholar. Actions are driven by passion, usually with limited regard for truth, as some of you may have noticed in a television program shown two evenings ago, focused on the damaging effects of hydro development in northern Quebec. Over-simplification and over-statement are the way to the viewers' hearts. Scientists are trained to do exactly the opposite. How they should behave in controversial matters, particularly when they work for government agencies, presents many difficulties to scientists who care deeply about wildlife, as most of us do.

With so much to be done, and very limited resources, we need to be guided by Peter Medawar's advice (*New Statesman* June 19, 1964) "No scientist is admired for failing in the attempt to solve problems that lie beyond his competence. . . . If politics is the art of the possible, research is surely the art of the soluble. Both are immensely practical-minded affairs."

In a Canadian Wildlife Service executive meeting last week, we were confronted by an example of the kind of junk generated by process-oriented bureaucrats—some advice on how to describe projects and programs so as to increase the likelihood of their acceptance by officials of Treasury Board and other central agencies, whose ignorance is matched only by their arrogance, and who can readily block almost any initiative, without regard to its merits. The paper excited a proper derision, but one phrase has stuck in my mind: proposals should be presented in "chewable chunks." Though it sounds like an advertisement for dog food, this is a useful idea, not only in marketing, but more importantly, in conducting and reporting research.

My final comment concerns the importance of leadership—an uncommon talent that seems even harder to exercise in partnerships than it did in the bad old days of hierarchies and people who knew their places. Effective leadership involves not only readiness to act but clarity of thought and determination. There have been remarkably few widely acknowledged leaders in wildlife conservation. Let me leave you with three questions. (1) Why are Aldo Leopolds so rare? (2) Where will the Leopold of the early 21st century come from? (3) Will you acknowledge her while she is still alive?



Special Session 9.
Managing Predator/Prey Populations

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Wolf Control: A Management Dilemma

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Introduction

Wildlife managers face an increasingly difficult task—to maintain and, in some cases enhance, wildlife diversity in the face of rapidly increasing demands on the landscape. Population growth, urban sprawl, increasing demand for resources and increasing backcountry travel are all placing tremendous pressures on wildlife habitat. It appears certain that management of the landscape and its resources will have to increase to maintain existing diversity.

Aldo Leopold (1933) described the tools and techniques that wildlife managers have at their disposal. Those techniques have not changed appreciably in 60 years. However, one of those techniques, predator control, is seldom used, particularly for large predators. Recent wolf (*Canis lupus*) control programs in British Columbia and elsewhere have generated such heated public controversy that there is little political will to support such programs. Indeed, it seems that some management agencies have been reluctant to implement research recommendations for wolf control because of the public controversy associated with the technique. For example, Edmonds

(1988) recommended wolf control to reverse declining caribou (*Rangifer tarandus*) numbers in westcentral Alberta. That recommendation has not been implemented.

This paper deals with the management of wolves for wildlife management purposes, i.e., the reduction of wolf numbers by management agencies to increase wolf prey numbers. The purposes of this paper are: (1) to describe the history of wolf control for wildlife management purposes in British Columbia; (2) to describe a case study of a recent wolf control program; (3) to discuss the social implications of wolf management in British Columbia; and (4) to present a strategy, presently being tested, for addressing this issue.

Historical Perspective

Historically, wolves were viewed as vermin in British Columbia. Shortly after the turn of the century until 1955, a bounty on wolves was in effect. From the late 1920s to the mid-1940s, wolf numbers appeared to be increasing in British Columbia in response to an increasing moose distribution (Hatter 1950, Bergerud and Elliott (1986). The increase in the number of wolves coincided with declines in caribou and moose populations (Bergerud and Elliott 1986) which greatly concerned guides, hunters and ranchers (Tompa 1983). As a result of these increased wolf numbers, the Predator Control Branch (PCB) was formed in 1947 with the mandate to reduce the number of predators damaging livestock and competing with man for ungulates.

Although largely undocumented, there is little doubt that this Branch was effective in reducing numbers of carnivores over extensive tracts of land. On mainland British Columbia, the primary technique used was the broadcast application of poison baits from fixed-wing aircraft. Jack Lay (personal communication: 1990), who was an employee of the PCB, believes that the program may have killed as many as 75 percent of the wolves in the province between of 1948 and 1955. Indeed, Mr. Lay contends it was the low number of wolves and coyotes (*Canis latrans*), as a consequence of the program, that resulted in the PCB being disbanded in 1963.

After the intense persecution of wolves during the 1950s, the Ministry of Environment began to replenish wolf numbers in wilderness areas by: ceasing poisoning programs in wilderness areas (1961); disbanding the PCB (1963); designating the wolf as a big game species; closing seasons in areas of low wolf numbers; and closing all trapping seasons (1966).

Ungulate survey data are not available during or after the period of intensive wolf control. However, Bergerud and Elliott (1986) present data suggesting that moose (*Alces alces*) and caribou numbers increased significantly during control, reached peak numbers by 1968 and began to decline after 1970.

In the mid-1970s, the Ministry of Environment, concerned over caribou numbers, supported research to determine the status of caribou in British Columbia (Bergerud 1978). That report (Bergerud 1978) hypothesized that provincial caribou populations were declining because of low calf recruitment as a result of predation and overhunting. The Ministry of Environment responded immediately by closing and shortening caribou seasons, ending female harvests and requiring compulsory inspection of all harvests.

Bergerud (1978) also hypothesized that moose populations were declining in areas of high wolf density. He compared moose calf recruitment rates between areas with high and medium wolf densities and found that, in areas with medium wolf densities (7 wolves per 400 square miles: 1,000 km^2) recruitment rates were just high enough to offset adult mortality in a hunted population. Where high wolf densities (13 wolves per 400 square miles: 1,000 km^2) occurred, recruitment rates were well below those required to maintain a stable population, even in an unhunted population.

In 1978, the Ministry initiated a three-year research project designed to determine the impacts of wolf control on the survivorship of caribou calves in northern British Columbia. Numbers of caribou and wolves were intensively monitored on two study areas and wolf numbers were annually reduced on one of the study sites before calving. Although the results of the study were confounded by severe weather, the researchers concluded that wolf control could result in increased caribou calf survival and that such increases would likely translate into increased recruitment unless severe weather conditions prevailed (Elliott et al. in preparation). Bergerud and Elliott (1986) reanalyzed data from this study and reported that caribou calf survivorship dramatically increased on the wolf removal site during the period of wolf removal and declined as wolf numbers were allowed to recover.

This study was the first attempt to quantify the effects of predation on ungulate population growth in British Columbia and was followed by similar research projects in northern British Columbia (Elliott 1984a), in central British Columbia (Herbert 1987) and on Vancouver Island (Atkinson and Janz 1991). These studies resulted in the implementation of operational wolf control programs in northeastern British Columbia (Elliott 1984b) and on Vancouver Island (Janz and Atkinson in preparation).

A Case Study in Wolf Control—Vancouver Island

Vancouver Island (Figure 1) is situated in southwestern British Columbia, within the Coast Mountains and Georgia Depression ecoprovinces (Demarchi et al. 1990). Four biogeoclimatic zones (Krajina 1965) are present on Vancouver Island: Coastal Western Hemlock, Alpine Tundra, Coastal Douglas-fir and Coastal Mountain Hemlock. The productive capability of the region is very high for both timber and wildlife and many of the timber/wildlife conflicts in the province have occurred here (Hebert 1979, Bunnell 1982).

Black-tailed deer (*Odocoileus hemionus columbianus* Richardson) are an important big game species on Vancouver Island. Before 1975, Vancouver Island supplied 30–45 percent of the total provincial deer harvest (Hebert 1979). Early research conducted on deer on Vancouver Island generally focused on the relationship between the species and its habitat (e.g., Wilms 1971, Jones 1975, Stevenson 1978, Rochelle 1980). These studies investigated the effects of logging practices on deer habitat and documented the importance of old-growth forests to deer. That understanding resulted in a habitat management initiative to identify and to defer logging of the important deer old-growth winter ranges on northern Vancouver Island (NVI) (Figure 1). Harvest management for deer was primarily through season and bag limit adjustments.

Presently, more than 100,000 acres (>40,000 ha) of old-growth forests have been deferred as critical winter habitat on Vancouver Island, primarily for the benefit of deer. Although the total value of this lumber is unknown, it was estimated in 1982 that 26,000 acres (10,400 ha) on NVI of this total deferral would annually support

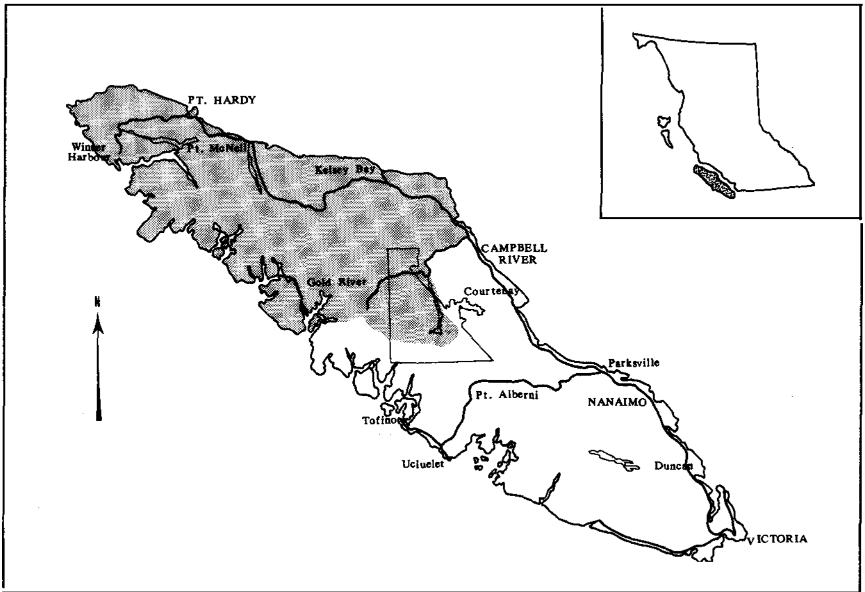

Figure 1. Southern and northern Vancouver Island.

a lumber harvest worth $11,606,000 and would employ 153 harvesting and manufacturing man-years of employment (B.C. Ministries of Environment and Forests 1983).

Deer numbers began to decline on NVI in the mid- to late-1970s. As surveyed by spotlight counts, deer numbers declined by 50 percent to 75 percent from 1976 to 1981 (Hebert et al. 1982, Jones and Mason 1983, Hatter 1984). Concomitant with the deer declines, hunter harvest also declined substantially (Figure 2). Those deer declines did not appear to be linked to winter severity or disease (Hatter 1984) and occurred in both hunted and unhunted watersheds (Jones and Mason 1983). Equally confusing to wildlife managers was while the declines were occurring on NVI, deer numbers were increasing on southern Vancouver Island (SVI) (Figure 1), where deer habitat was judged to be of lower capability (Janz and Hatter 1986).

Wolves on Vancouver Island

Records on the historical abundance and distribution of wolves (*C.l. crassodon*) on Vancouver Island are scarce. Before the 1950s, lack of access on NVI limited wolf sightings. Longtime residents of NVI recall the occasional wolf sighting in the 1950s but such sightings were rare. Coastal islands between Vancouver Island and the mainland were reported to support large numbers of wolves at infrequent intervals.

Records from SVI are somewhat better. Bounty records (on file) indicate that wolves were present but infrequently killed on SVI during the first four decades of the century. G.W. Smith (Wildlife Branch files, Nanaimo: 1979) conducted interviews with cougar hunters, guides, predator hunters and conservation officers who

Figure 2. Deer harvest trends and number of hunters on Vancouver Island.

lived and worked on Vancouver Island from 1903 to 1979. Based on these conversations, wolves apparently were present, although never abundant, and increased to a high point on SVI around 1940. They started declining thereafter, and by the 1950s were seldom seen.

The reasons for wolf declines on SVI and possibly on NVI are unclear. It is unlikely that the widespread use of poison played a role on Vancouver Island as it did elsewhere in the province. Although poison was used to control wolves on some of the offshore islands, it was not widely used on Vancouver Island (E. Samenn personal communication: 1991). Most predator control activity on Vancouver Island was focused on cougars and control officers were reluctant to use poison baits due to the risk to cougar hounds. Disease could have played a role. Mange was reported but only rarely.

Concern over the status of wolves resulted in total protection from hunting and trapping. By 1970, an "endangered species" designation was considered for the Vancouver Island wolf (Hebert et al. 1982). However, wolf sign and sightings began to increase in the early 1970s and, by 1976, wolves were regularly observed throughout Vancouver Island. Numbers increased to the extent that the hunting season was reinstated in 1977 and the trapping season in 1979. From apparently very low numbers, the wolf population on Vancouver Island expanded so much that, in less than a decade, wolves were considered abundant. Emigration of mainland wolves was speculated to be the source for repopulation, assisted perhaps by a natural increase in relict populations in the isolated northwest coast of the Island. A taxonomic study of British Columbia wolves by Friis (1985) lent credence to these speculations. By comparing skull characteristics among pre- and post-1950 Vancouver Island and mainland wolf specimens, Friis (1985) concluded that the original Island population, while not extirpated, could not be distinguished from wolves inhabiting the coastal mainland.

Wolf/Deer Relationships

In the late-1970s, the Ministry initiated and supported research projects on NVI to determine the relationships between deer and wolves. Scott (1979) studied two wolf packs and estimated wolf densities within summer/fall home ranges at 66–100 per 400 square miles (1,000 km^2). Hebert et al. (1982) determined that deer population trends were associated with wolf activity. The largest declines in deer numbers occurred within the 90 percent home range of wolf packs and the largest increases occurred in the buffer zone between pack home ranges. By 1981, however, the buffer zone was eliminated by the expansion and overlapping of wolf pack ranges, in response to declining prey availability (Hatter 1984). Hatter (1984) investigated the factors affecting deer population growth on NVI and determined that wolf predation was the limiting factor.

Experimental Control

To understand the role of wolves in regulating deer numbers on Vancouver Island, and to determine the effects of wolf control on the population ecology of wolves, the Wildlife Branch initiated an experimental wolf control program in 1982. The study was designed to allow comparisons between a wolf removal zone (RZ) and a non-removal zone (NRZ) and between pre- and post-treatment periods within zones (Atkinson and Janz 1991). Wolf densities were estimated using radio-collared wolves and wolf sign. Deer population trends were monitored by summer productivity counts (fawns/100 does), spring recruitment (percent juveniles) and spotlight counts (deer/km) (Harestad and Jones 1981).

Over the four-year study period, 64 wolves were killed in the RZ and five wolves were trapped and collared in the NRZ. Wolves in the RZ were reduced from an initial estimated density of 44 wolves per 400 square miles: 1,000 km^2 to a low of 4–5 wolves per 400 square miles (1,000 km^2) in the winter of 1984/85. Initial wolf densities in the NRZ were similar to those in the RZ and were stable to slightly increasing during the course of the study (Atkinson and Janz 1991). Variable annual deer recruitment within the NRZ was puzzling. Recent revelations of substantial unreported illegal killing of wolves has prejudiced the data from the NRZ. Local residents may have killed as many as 22 wolves within the NRZ between 1982 and 1986. Those wolves were shot, trapped and run over, apparently in full knowledge of the affects of such action on the research project.

Deer productivity, juvenile recruitment and the population index all substantially increased during wolf control and declined abruptly when control was terminated (Table 1). As well, fall wolf density was found to be significantly related to fawns/100 does (F = 15.94; df = 1,3; r = .92; $.025 < p < .05$; Figure 3) and to subsequent spring recruitment (F = 19.2; df = 1,3; r = .93; $.01 < p < .025$; Figure 4). Atkinson and Janz (1991) reported that an annual wolf reduction of 59 percent of the fall population resulted in a declining wolf population. Wolf densities near or below 7–9 wolves per 400 square miles (1,000 km^2) resulted in high deer recruitment (>20 percent) and an increase in the deer/mile (deer/km) index).

Some important lessons were learned from this project: trapping was a viable, albeit expensive, form of wolf control; by controlling wolves, deer numbers would

Table 1. Impacts of wolf control on deer population trends in the experimental removal area.

Year	Fawns per 100 does	Percentage juveniles	Deer per kilometer
1976	83.7	23.9	11.6
1977	16.9	11.4	12.2
1978	65.7	13.6	11.4
1979	15.0	7.5	8.9
1980	14.7	7.3	7.0
1981	16.7	9.6	4.3
1982	15.8	10.5	5.5
1983[a]	44.3	3.9	3.4
1984[a]	52.4	19.4	4.8
1985[a]	71.6	25.3	6.4
1986[a]	61.5	24.8	7.2
1987[a]	36.1	21.0	6.9
1988[a]	74.5	21.5	8.8
1989[a]	61.9	26.2	10.9
1990	56.7	24.7	12.1

[a]Years of wolf control (1983–86 experimental control; 1986–89 operational control).

respond quickly, and that when control was stopped, wolves responded quickly; and despite considerable public information and education on the value of the research project, some residents were distrustful and mounted their own control programs within the NRZ. Such action affected the wolf population within that zone.

Operational Wolf Control

Ministry staff on Vancouver Island believed that the public should be informed to support actions deemed necessary to rebuild deer herds. That commitment resulted in many public information/education meetings, beginning in 1979, to discuss the problem of declining deer numbers (D. Hebert personal communication: 1990). Citizens at those meetings represented the full spectrum of opinion on wolf management. The technique of wolf control was freely discussed at those meetings and resulted in considerable polarization of opinion. That conflict resulted in a major delay in implementing reactive management. Meanwhile, neither deer nor wolf management objectives were being met.

Janz and Hatter (1986) reviewed all existing data relating to deer on Vancouver Island and recommended implementation of an operational wolf control program. The objectives of the control program were to enable recovery of important deer herds and to ensure the long-term maintenance of the predator-ungulate system at viable numbers. Because of the controversial nature of wolf control programs, the final decision for the program was elevated to the political level. Ministerial approval for a three-year control program was received in the spring of 1986 and the program began that summer.

Wolf removal on NVI occurred where habitat prescriptions for deer had resulted in old-growth logging deferrals and on SVI in watersheds with declining deer populations (Janz and Hatter 1986). Registered trappers were trained and equipped to

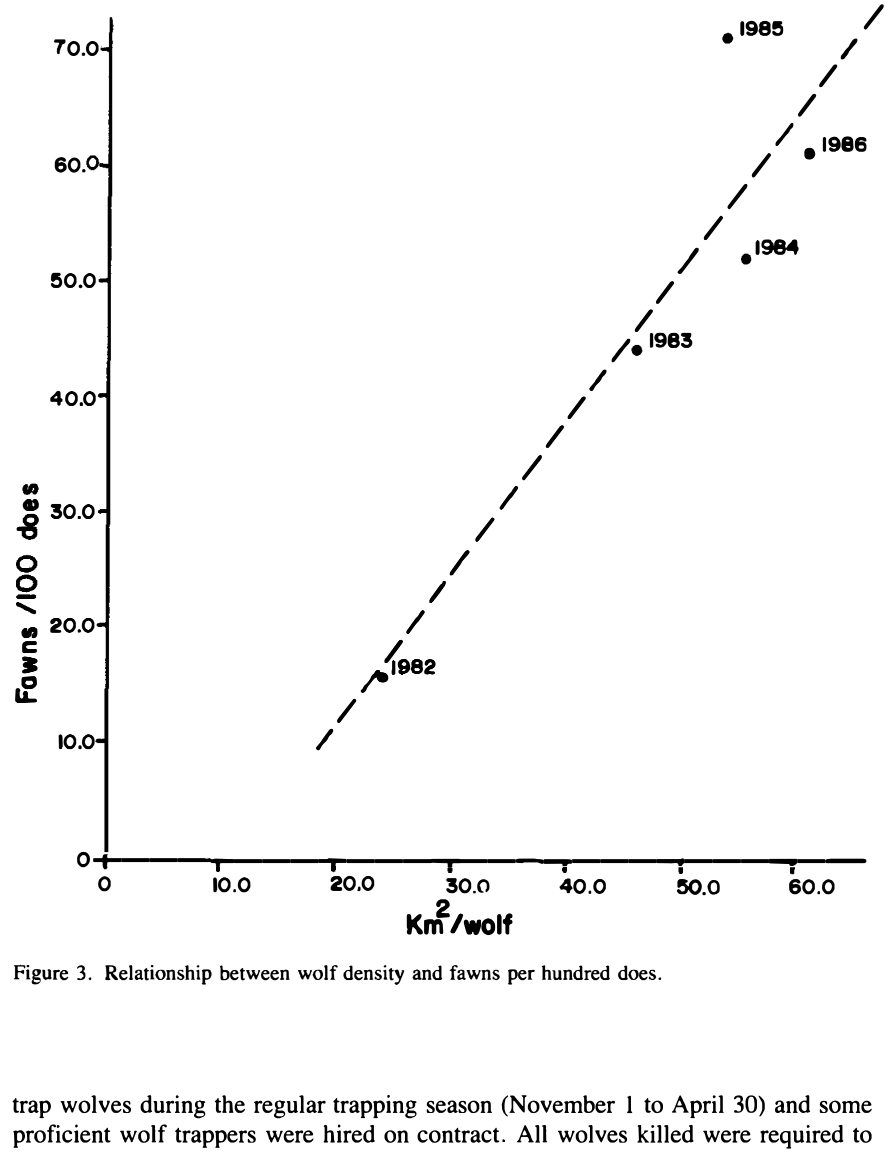

Figure 3. Relationship between wolf density and fawns per hundred does.

trap wolves during the regular trapping season (November 1 to April 30) and some proficient wolf trappers were hired on contract. All wolves killed were required to be submitted for inspection.

Program evaluation consisted of recording the number of wolves removed and monitoring the subsequent responses of deer and wolf populations. Antlerless deer seasons were closed in all areas receiving wolf control, and bag limits for bucks were reduced from three to two.

An estimated 255 wolves were killed between the summer of 1986 and the spring of 1989, most (81 percent) were removed by trapping. Table 2 outlines the number of wolves removed from SVI and NVI and estimates the wolf populations pre- and post-control. The post-control average wolf density for Vancouver Island was 8–12

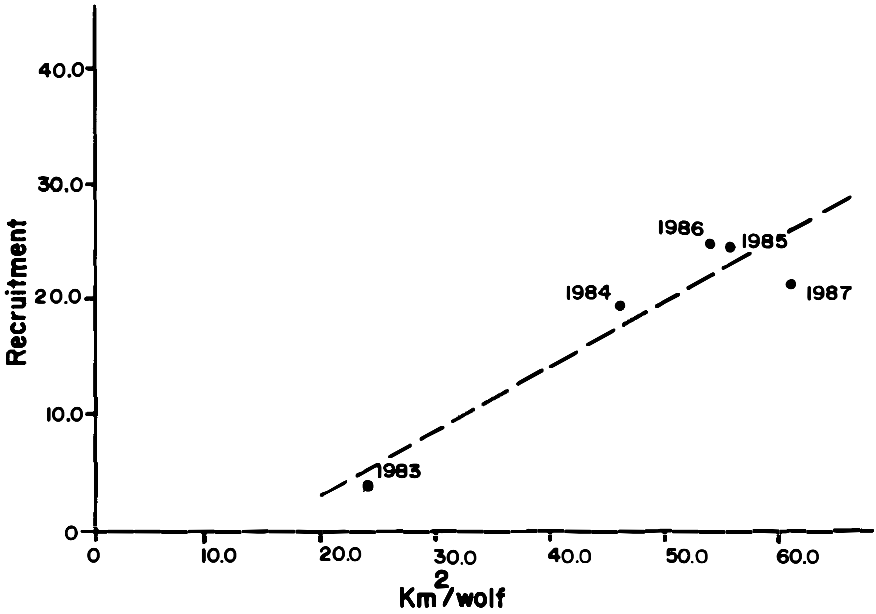

Figure 4. Relationship between wolf density and spring deer recruitment.

wolves/400 square miles (1,000 km^2). This estimate is within the range of viable wolf population in other regions of North America (Ballard et al. 1987).

Deer population responses within monitored watersheds from 1976 to 1989 on SVI and NVI are indicated in Table 3. The trend of increasing deer populations evident during the experimental control program was again observed. Perhaps more revealing were deer abundance data from two watersheds on NVI that received no wolf control—Mahatta River and the Victoria Lake area.

Spring deer counts in the Mahatta River in 1974 resulted in counts of 14.0 and 16.0 deer/km. In 1977, during the period of rapid wolf expansion on NVI, counts were again conducted in this watershed, one in an area of "extensive wolf use" (as determined by scats, howling and kills) and another in an area of "minimal wolf use." In the former area, investigators recorded 7.6 deer/km and 4 percent fawns;

Table 2. Wolf population estimates for SVI and NVI pre- and post-control, and the total number of wolves removed during control.

	Pre-control	Number wolves removed (1986–89)	Post-control
SVI	180–250	156	135–185
NVI	250–340	99	130–200
Total	430–590	255	265–385

Table 3. Deer population responses (deer/km) within monitored watershed from 1976 to 1990.

	SVI			NVI			
Year	Shawnigan	Chemainus	Nanaimo R[a]	Nimpkish	Adam	Eve	White[b]
1976			7.5	11.6	10.2	9.4	9.5
1977			9.9	12.2	7.4	4.8	10.0
1978			17.4	11.4	8.1	4.4	8.3
1979			19.6	8.9	8.4	5.2	8.1
1980			19.1	7.0	6.1	7.1	8.7
1981			16.9	4.3	4.8		4.6
1982			15.2[c]	5.5	4.8		3.5
1983			11.8[c]	3.4[c]	5.5	6.1	6.9
1984			10.8[c]	4.8[c]	4.9	4.5	6.8
1985			9.6[c]	6.4[c]	6.5	7.9	9.2
1986		12.3	8.7[c]	7.2[c]	6.7	5.7	12.8
1987	6.0[c]	12.3[c]	9.7[c]	6.9	6.4[c]	10.6[c]	16.8[c]
1988	9.4[c]	12.3[c]	11.5[c]	8.8[c]	10.8[c]	14.3[c]	19.8[c]
1989	10.8	13.0[c]	11.4[c]	10.9[c]	11.8[c]	14.1[c]	19.2
1990	15.0	15.3	9.0	12.1	9.3	10.8	21.0

[a]Intensive control in 1982 and 1983 in support of habitat research.
[b]Heavily trapped by local registered trapper from 1982 to 1986 inclusive.
[c]Years of wolf control

in the later, 16.1 deer/km and 17 percent fawns. In 1988, the area was again inventoried and no deer or deer sign were observed. Road access into the Mahatta was unavailable until 1988, so previous hunting pressure was relatively light.

The method of data collection in the Victoria Lake area was different during the early 1970s but the trends are identical to those found at Mahatta River. In 1973, inventory staff reported an index of 3.5 deer/km. A similar survey in 1974 reported 1.5 deer/km. These figures were based on total road length surveys (i.e., including forested habitat that could not be counted) and are conservative estimates compared to present counting techniques (Harestad and Jones 1981). Surveys conducted in 1987 and 1988 both reported estimates of 0.5 deer/km.

Data from the hunter sample also suggested increasing deer numbers as a result of wolf control. The total number of deer killed, the number of hunter days per kill and the total number of hunters are depicted in Figure 2. Not only has hunter effort declined and the total number of deer killed increased, but also the total number of hunters increased on Vancouver Island in 1989, the first time since 1980.

A wildlife manager's perspective on the program is that it was successful. Deer numbers increased in many watersheds for the benefit of other predators, primarily cougar (*Felis concolor*) and black bear (*Ursus americanus*), greater recreational opportunities were provided for both the hunting and viewing public, and viable populations of wolves were maintained. Total program costs over three years were $132,000.

The Vancouver Island wolf control program generated its share of controversy (e.g., *Vancouver Sun* article Dec. 18, 1986), but nowhere near that generated by other wolf control programs. The reasons are unclear but are probably related to the following: trapping as a means of control is less controversial than aerial gunning;

considerable public education/information had been undertaken by Ministry staff before the control program; and this program was run concurrently with a wolf control program in northeastern British Columbia (Elliott 1984a, 1984b) that was very controversial and may have deflected public attention away from the Vancouver Island project.

Social Aspects of Wolf Control

Until the late-1960s, British Columbians were either supportive or indifferent to wolf control (Hoffos 1987). Now many conflicting forces have an interest in wolf management in British Columbia. Among these are hunters who wish to pursue their activity with a reasonable chance of success and guide-outfitters who wish to maintain a viable business. There are trappers who derive direct economic benefit from wolves, and there are native sustenance hunters who suffer greatly when wolves maintain prey numbers at low levels. As wildlife managers we know all of these "traditional" client groups.

To balance those who see wolf control as occasionally necessary, there are a host of others who believe wolf control is unacceptable. The latter have become increasingly active in British Columbia and elsewhere and have had a severe impact on program planning and delivery. In British Columbia, such groups have resorted to civil disobedience and have also successfully used the courts to stop an on-going control program. Clearly, these groups do not feel that their interests are being addressed by wolf control. Although not well known or understood by wildlife managers in British Columbia, such groups view control programs as a threat to the continued survival of wolves in British Columbia (Hoffos 1987).

When issues are so controversial that they create divisive actions within and among organizations that traditionally support management agencies then there are no winners: the advocacy organizations use valuable resources that could be focused on other issues affecting wildlife and wildlife habitat; the management agencies lose public support and credibility, which can translate into a loss of resources; and ultimately, the wildlife resource itself suffers.

The seemingly obvious solution then would be to abandon controversial projects such as wolf control. But consider for a moment the costs of not controlling wolves. First, let us use the above case example. Data from those watersheds on NVI where wolves were not controlled show what may have happened in the absence of wolf control on Vancouver Island. Wolves and deer have been maintained at very low levels for the past 15 years. The mechanism for this wolf/deer system being maintained at such a low equilibrium is not known but we suspect a "predator pit" (Bergerud 1983, Gauthier and Theberge 1987) due to the availability of alternate prey (e.g., beaver, elk and beach scavenging). It is unclear if similar declines would have occurred over the rest of Vancouver Island, but we must keep in mind that deer population trends in other parts of Vancouver Island, before control was implemented, were similar to those recorded on NVI.

Perhaps of more significance is the habitat issue. As mentioned earlier, there are millions of dollars of old-growth forests tied up in long-term deferrals, primarily for deer winter habitat. If deer production objectives are not realized for these areas due to wolf predation, it greatly weakens the argument for preserving those deferrals, most of which are up for renegotiation within the next five years. If these deferrals are lost, all species that rely on those forests will be at risk, including wolves. In addition, the application of various silvicultural techniques to enhance deer and elk habitats have received significant effort on Vancouver Island since 1981 (Nyberg and Janz 1990). Similar to old-growth deferrals, the implementation of these activities is difficult to justify when ungulate numbers are far below habitat carrying capacity.

Provincially, there is another issue related to wolf control that must be considered. Caribou herds in central British Columbia are at risk due to predation by wolves (Seip in press). Research has indicated that wolf control would result in rapid recovery of these caribou (Hebert 1987). If these herds are lost, the genetic diversity of caribou as well as the biological diversity of British Columbia will be affected. Allowing such an extirpation would be against the conservation mandate of the British Columbia Wildlife Branch.

Finally, evidence from our experience on Vancouver Island and elsewhere in the province shows that if wildlife managers do not address the concerns of those being affected by wolf predation, then they will take matters into their own hands. Remember that a substantial number of wolves were removed by local residents from the experimental non-removal zone despite the continued presence of project researchers and a strong enforcement presence (compared to other parts of the province). We believe that the future of the wolf rests largely with those who share the landscape with it. If we ignore the interests of those who are affected by low prey numbers as a result of wolf predation, we may do so at great costs to wolves and other carnivores.

Strategy for Future Wolf Control

We contend that wildlife managers must retain the option to control wolves where appropriate. We agree with Peek (1986) that wolf control is a management technique that must be used with discretion and judgment, in an open and forthright manner. However, the problems in maintaining this option are challenging. How do we include the broader public constituency in resource management decisions? How do we address the public concern relating to the long-term viability of the species? How do we ensure that proposed control programs are technically sound and are being driven by realistic management objectives? How do we address the powerful imagery of wolves dying in a trap or being shot from aircraft?

In British Columbia, we are attempting to address those issues. In 1988, the Ministry of Environment established a review process for all wolf control proposals that includes a public advisory group, the Wolf Working Group (WWG). The WWG has representatives from those public groups interested and concerned about wolf management. When a proposal is prepared for wolf control, it is first technically reviewed by a four-person panel of Ministry and non-government wildlife biologists. The two panel members from outside government are selected by the WWG. The WWG makes recommendations to the Ministry on the merits of the technical audit and the control proposal. The final decision on each proposal will be made by the Ministry.

The Ministry is also exploring the possibility of establishing kill-free areas for large carnivores that will be consistent with its broader biodiversity mandate. That concept has recently been supported by a parallel proposal brought forward by the World Wildlife Fund (Canada) (1990), and is supported by many members of the

WWG. If such areas support viable wolf populations, public concern over the long-term status of wolves in British Columbia may diminish.

Finally, there is the very powerful imagery of wolves dying at the hands of man to achieve human-related objectives. Limited research on this topic suggests that most support controlling wolves in livestock conflict situations (Kellert 1986, Hoffos 1987) but that support for wolf control in wildlife management situations is strongly polarized (Kellert 1986). Arthur et al. (1977) reported that public acceptance of wolf control would be enhanced if non-killing techniques were applied. The recent innovative research of Boertje et al. (1990) into non-lethal forms of predator control holds future promise.

Wolf management remains a dilemma for wildlife managers in British Columbia and elsewhere. It is known that wolves, and other large predators, can have a regulatory affect on ungulates (e.g., Mech and Karns 1977, Gasaway et al. 1983, Larson et al. 1989). Less clear is the role that predation plays in initiating such declines (Gauthier and Theberge 1987). However, low numbers of ungulates clearly affect not only those wanting to use this resource, whether for hunting or appreciative use, but also places the habitat of those species at risk (Gasaway 1989). Wolf control programs have been demonstrated to increase ungulate numbers (Bergerud and Elliott 1986, Gasaway et al. 1983, Farnell and MacDonald 1987), but such programs have been delivered at substantial costs to the agencies involved due to negative public reaction. Hopefully, the process and strategy now being refined in British Columbia, perhaps combined with non-lethal forms of wolf control, will result in greater understanding and public acceptance of wolf control. If not, there is little chance that the political will exists to authorize such programs and the ultimate losers in such conflict situations will be wolves, other wildlife and wildlife habitat.

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Prey Management for the Florida Panther: A Unique Role for Wildlife Managers

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Introduction

Public demand has placed the recovery of the endangered Florida panther (*Felis concolor coryi*) as a high priority for several state and federal natural resource agencies. More than 100 years have elapsed since panther management consisted of a $5.00 bounty for panther scalps. While panther/prey relationships have been studied only recently, the actions by individuals and government agencies during the first two-thirds of this century determined today's management challenge involving the application of biological theory to a complex political reality. Further, the introduction to Florida of an exotic artiodactyl over 400 years ago may have been critical, albeit unintentional, to the persistence of panthers today.

The interaction of significant biological threats to a small population of large predators, the demand for sport harvest of white-tailed deer (*Odocoileus virginianus*) and wild hog (*Sus scrofa*) on public lands, the pressures on private wilderness landscapes to provide urban and agricultural space, and the philosophical differences among responsible government agencies have created a conservation challenge unique in North America. In southern Florida, the traditional role of wildlife agencies as controllers of predators for the increase of prey has been reversed. Panther management in recent years has involved a series of prey harvest regulation changes, vehicle access restrictions, land acquisition strategies and intensive field research that has resulted in changes to the outdoor experience for hunters and non-hunters with debatable impacts on panthers.

As high-quality private lands are developed, increasing pressure will be placed on remaining public lands for panther conservation and human recreation. In light of private land development, the ultimate challenge facing public land managers in southern Florida is maintaining a panther population on a smaller land area (Maehr 1990a). An important aspect of management on this increasingly isolated and denatured landscape will be the increase of prey for an endangered predator. We present a brief review of historical events preceding the endangered status of Florida panthers and a more detailed review of recent efforts to manage this predator and its prey. Patterns of prey distribution, herd condition and harvest information are examined in regards to panther distribution, movements and reproduction.

Study Area

A rapidly increasing human population in southern Florida has stimulated some of the fastest growing urban and agricultural centers in the nation. Changing land uses are manifest in spreading housing developments, burgeoning citrus and vegetable production, and concomitant reductions in the value of these lands to many wildlife species. The loss of extensive forest cover and increased human activities on many of these private urban and agricultural enterprises has eliminated Florida panthers and their prey from many traditionally occupied areas or has isolated them in increasingly fragmented islands.

Few areas in eastern North America contain such an extensive network of public land and diversity of government stewards as southern Florida. The major properties in southern Florida include Big Cypress Seminole Indian Reservation, Miccosukee Indian Reservation, Big Cypress National Preserve (BCNP), Everglades National Park, Holey Land and Rotenberger Wildlife Management Areas, Florida Panther National Wildlife Refuge, Fakahatchee Strand State Preserve, and the Water Conservation Areas (Figure 1). These adjoining state and federal properties total 1,236,000 ha. In addition, within the next few years, over 80,000 ha will be acquired or are under consideration for purchase in southwestern Florida. This diverse array of property exhibits a comparable variety of management philosophies and responsibilities. Where hunting occurs, as with Big Cypress National Preserve and the Water Conservation Areas, management responsibilities are shared between the Florida Game and Fresh Water Fish Commission (GFC) and the National Park Service (NPS)

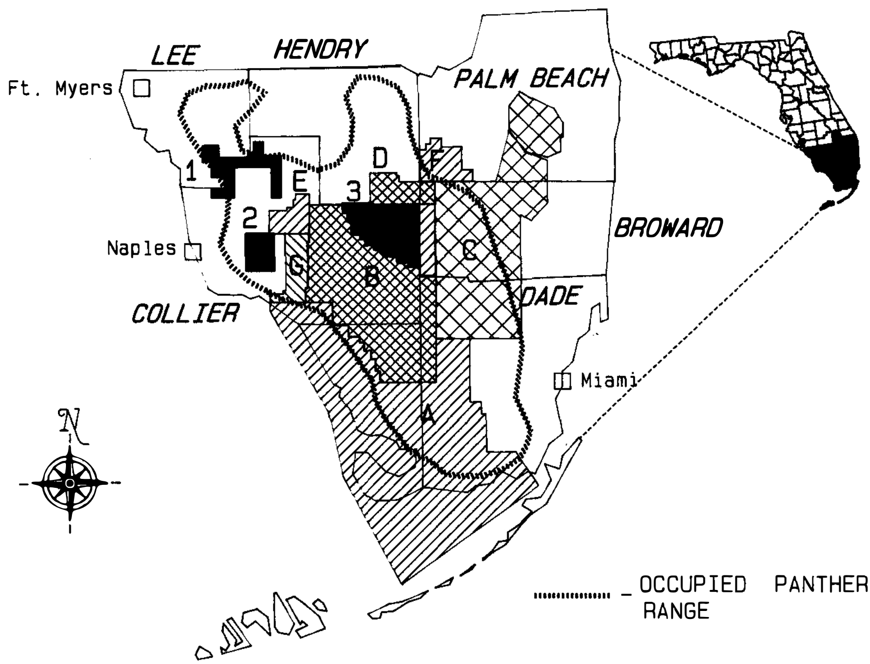

Figure 1. Public lands in southern Florida: A, Everglades National Park; B, Big Cypress National Preserve; C, Water Conservation Areas; D, Big Cypress Seminole Indian Reservation; E, Florida Panther National Wildlife Refuge; F, Rotenberger and Holey Land Wildlife Management Areas; G, Fakahatchee Strand State Preserve. Future public lands include 1, Corkscrew Regional Ecosystem Watershed, 2, southern Golden Gate Estates, and 3, Big Cypress National Preserve addition lands.

or the South Florida Water Management District (WMD), respectively. On other areas such as Florida Panther National Wildlife Refuge (U.S. Fish and Wildlife Service [FWS]). Fakahatchee Strand State Preserve (Florida Department of Natural Resources [DNR]), and Everglades National Park (National Park Service), hunting is not allowed and efforts are directed towards ecosystem management and non-consumptive human uses. The Indian Reservations are characterized by a variety of land uses including residential, citrus and tourist attractions.

Southern Florida is a flat, poorly drained, subtropical landscape that includes a variety of vegetation communities. The climate is tropical savanna with a mean annual temperature of 23°C (extremes of − 2°C to 38°C) (Duever et al. 1986). Annual rainfall averages 140–150 cm. About 60–80 percent of the total precipitation occurs from June to October, and dry season conditions can prevail from November through May (Craighead 1971). Elevations range from sea level near the coast to 7.6 m MSL in the interior (Wade et al. 1980). Flooding, frost and fires are important environmental influences on the distribution and kinds of native plants found in southern Florida (Craighead 1971, Wade et al. 1980). Important vegetation communities include pine flatwoods, cypress swamp, hardwood hammock, mixed swamp, thicket swamp, freshwater herbaceous wetlands (Davis 1943) and improved pasture. Important truck crops include tomatoes, green peppers, cucumbers and squash. Fields that have been cleared and drained may range in size from isolated 1-ha plots to conglomerations covering several square kilometers. Much of the native vegetation in and around the major agricultural areas exists as elongated cypress strands or other wetlands dependent upon poor drainage and therefore is unsuitable for conversion to citrus or vegetables.

Hunting is a popular activity that has been much less landscape disruptive than agriculture or urbanization and has been a traditional activity in southern Florida since first occupied by humans. Native Americans in southern Florida, principally the Calusa and Tequesta cultures, depended heavily on white-tailed deer and other wildlife species for food and implements (Wing 1965). The development of modern firearms and self-propelled off road vehicles created hunting conditions prevalent today. Jansen (1987) surveyed hunters in BCNP and found the two most popular game animals were deer and hogs.

While a variety of hunting methods are employed in southern Florida, this area is the birthplace of the swamp buggy. These highly variable, home-made vehicles are usually built around a four-wheel-drive truck or jeep chassis, with large tires for ground clearance and flotation, and with exposed seats and instrument panel positioned on an above-engine platform for enhanced visibility (Figure 2). Swamp buggies provide access to areas previously impervious to vehicles or too remote for short term excursions. Throughout southwestern Florida's remaining wild lands a network of trails traversing dense forests and open marsh has been established over decades of buggy travel.

Opportunities for hunting in southern Florida have changed as land has been bought and sold, subdivided and developed, or transferred from private to public ownership. As recently as 40 years ago, travel was unimpeded by highways, canals or fences. Hunting today is done on public areas such as the BCNP or on private ranches where the rights to hunt are leased to individuals or small groups. Hunting leases may cost from $8.00 to $25.00 per ha and cover up to several square kilometers (M. Ramsey personal communication).

Figure 2. Homemade swamp buggy designed for off-road travel through a wide variety of hydrological, soil and vegetation conditions encountered in the Big Cypress region.

Methods

To document kinds and impacts of prey management we examined information collected on a variety of management and research activities. These included data from ongoing research projects, data routinely collected by area wildlife managers and official agency records. The white-tailed deer is the only prey species which has been intensively investigated in the study area. Field work has focused on the BCNP between 1983 and 1990. Deer track count surveys and spotlight surveys were conducted on the Corn Dance (CD) and Bear Island (BI) units, and populations estimated (Tyson 1959) and sex ratios were calculated during that period. Only deer which could be positively identified as adult and/or exhibiting antlers were included in sex ratios.

Does were collected from both management units beginning in 1984. Quarterly collections of six deer from each unit were conducted for two years and then reduced to annual fall collections through 1990. Necropsies were performed as outlined by Nettles (1981). Physical condition values were assigned following Stockle et al. (1978) and abomasal parasite counts were calculated according to Eve and Kellogg (1977). Reproductive status including pregnancy rates, productivity, conception and fawning dates were determined utilizing standard methodology (Labisky and Richter 1981).

Data on harvested animals were collected at hunter check stations where standard physical measurements were recorded. Deer were aged by tooth eruption patterns and wear (Severinghaus 1949). Hunting pressure was estimated by conducting vehicle surveys on each Saturday during the hunting season.

Direct responses of doe deer to hunting were measured in BI beginning in 1986. Does were captured, radio instrumented and located on a weekly basis. Home ranges, mortality (including illegal harvest), productivity and neonate fawn mortality were all estimated using telemetry data and observations of collared deer and their offspring.

Results and Discussion

A variety of vertebrate taxa are represented in the panther's diet, ranging from birds to domestic livestock. However, from frequency of occurrence and biomass calculations, white-tailed deer and wild hog are the most important species (Maehr et al. 1990). While armadillos (*Dasypus novemcinctus*) and raccoons (*Procyon lotor*) are regularly taken, they provide a small proportion of biomass to panthers.

History of Events Affecting Panthers and Prey

Pre-1900. In 1539, European wild hogs were introduced near Big Cypress in the Charlotte Harbor area by Hernando DeSoto (Towne and Wentworth 1950, Belden and Frankenberger 1977). Wild hogs were well established in the Big Cypress prior to 1900.

Deer harvest may have been substantial during these early years. McCauley (1887) estimated that Seminole Indians in southern Florida harvested 2,500 deer annually. Most deer were harvested for subsistence, trading or bartering. The first regulation governing deer harvest in Florida was passed in 1828 when night-lighting or "fire hunting" was prohibited. However, law enforcement was not provided until 1897. The most significant land use in southern Florida was raising cattle on native range. The landscape was little altered during this time (DeBellevue 1976).

1900–1940. Major statewide regulations protecting deer were enacted early in this century. These regulations included seasons, bag limits and more restrictions on methods of hunting. At the turn of the century, Florida enacted laws prohibiting the export and sale of game animals. These actions, together with the Federal Lacey Act of 1900, marked the beginning of effective control on market hunting and commercial profiteering of Florida's white-tailed deer.

It was also during this period that the nine-banded armadillo became established. The Florida population was apparently established from three releases on the Atlantic Coast between 1920 and 1930. These groups spread and eventually occupied most of the peninsula (Humphrey 1974). While armadillos are common in southern Florida, they occur only sporadically throughout much of the Everglades and Big Cypress due to hydrological extremes.

This time period also marked the beginning of major human encroachments into the area. These included the completion of the Tamiami (Tampa to Miami) Trail in 1928, the completion of a railroad from Immokalee to Everglades City and the initiation of commercial logging, primarily for cypress (*Taxodium distichum*) and slash pine (*Pinus elliottii* var. *densa*).

Commercial harvest of wildlife peaked during the early part of the 20th century. Both Indian and white hunters participated in the exploitation of the region's wildlife resources. While wading bird plumes and alligator hides dominated this industry, furbearing animals were also important. In the 1920s, fur dealer J. Fohl of Ft. Myers was handling 5,000 raccoon skins annually (Nash 1935). Nash reports that the Lopez brothers harvested approximately 500 raccoons in two months in the Monroe County Reservation located in southern Big Cypress. Dan House, another trader in Naples, reported shipping up to 2,500 raccoon hides during the middle of this period (Kersey 1975). Deer hides were bought and sold by the pound but trading records were minimal. Many deer hides and the meat were utilized by trappers and local residents rather than traded. Kersey (1975) observed that the era of significant Seminole trade in this region lasted less than 50 years (1880–1930).

1940–1970. During this period continued development and increased human activities occurred throughout the area. Alligator Alley, the precursor of I–75, was completed in 1970. This highway connected Naples with Ft. Lauderdale and represented the first major road through the Big Cypress. It also represented a significant problem for panthers as about one animal per year was killed by vehicles until the construction of wildlife underpasses in the late 1980s. Large scale logging also occurred. Lee Tidewater Cypress harvested most of the large virgin cypress stands while the Jones Lumber Company logged many of the remaining pinelands in the Big Cypress (Tebeau 1957). These activities expanded and improved upon the oxcart and foot trails which provided limited access for subsistence and market hunting.

While market hunting had significantly declined by 1940, subsistence hunting was still prevalent through much of this period. However, by 1970 true subsistence hunting had declined dramatically. Recreational hunting increased as swamp buggies and improved access provided opportunities for shorter duration excursions into this area. Much of this wilderness was treated as "open land" and hunters often built camps in remote areas with little regard for property ownership. Everglades National Park was created and the Water Conservation Areas were established in the Everglades in 1947. In the Big Cypress area, the Collier, Big Cypress and Devil's Garden Wildlife Management Areas were established in the 1950s. Unfortunately these management areas were short lived as landowners resorted to more lucrative land-altering economic enterprises.

From 1940–1943 extensive efforts were undertaken to eradicate "Texas Cattle Fever" (*Babesia bigemina*) by killing deer throughout Florida (Harlow and Jones 1965). In the Big Cypress, 4,000 deer were harvested by professional hunters in 1940–41. This was done in order to eliminate a potential reservoir of this disease and the tick identified as its vector (Davis 1943).

Major land development pressures were initiated and expanded during this period. Agriculture, particularly in the interior uplands expanded significantly, especially in northern Collier County. Extensive farms developed along Tamiami Trail near Ochopee and eastward in what would eventually become BCNP. During the latter part of this period Florida's last major swamp land sale also occurred in the western Big Cypress. The Golden Gate area just east of Naples was subdivided and drained by a series of canals. Excavated fill was used to create a network of roads over a 160 square mile area. Lots ranging from 1.25–5.0 acres were sold mostly to out of state investors in one of the largest land sales operations ever undertaken (Carter 1974).

In the extreme eastern portion of the Big Cypress work began on a major regional airport. This facility, known as the ''Jetport,'' was being constructed by Dade County and, by 1969, a major runway and taxiway had been constructed.

By the end of this period the Wildlife Management Areas in the Big Cypress had been dissolved and hunting was governed by Statewide regulations. These regulations included established seasons, a five-inch antler (''buck'' only) regulation and other restrictions on harvest. In at least some portions of the area, deer had responded to improved habitat as the result of logging and protection from overharvest. Deer flourished, particularly in the Fakahatchee Strand, and during extremely high water conditions in 1968–69, a deer die-off occurred. A special either sex deer hunt was held and 289 deer were checked with an estimated harvest of 750. These animals had high APCs and poor physical condition values indicative of a deer herd exceeding carrying capacity (Eve and Kellogg 1977).

1970–1980. The decade beginning in 1970 was important for prey species, even though prey management still had not been identified as critical for panther survival. The status of the Florida panther was officially designated by the USFWS as endangered in 1973, although its true biological condition was unknown.

The Fakahatchee Strand State Preserve (FSSP) was created in 1972. It was in this strand that the remaining panther population was first identified (Belden and Williams 1976). Both panther sign and road kills adjacent to this strand documented its importance.

Construction of the Dade County Jetport in the eastern Big Cypress stirred another controversy. The Dade Collier Jetport was proposed as a regional airport serving all of southern Florida. If fully developed, this facility would have promoted secondary and tertiary growth throughout the eastern Big Cypress. Fortunately, an 11th hour attempt to block this facility was successful and the BCNP was created by Congress in 1974. This preserve was created to ''protect and enhance the floral, faunal, recreational and hydrological values'' of the region and to provide for the public use and enjoyment thereof (PL 93–440). Coupled with other protected areas, the 228,000 ha BCNP provides an important landscape for the Florida panther and its prey.

By the end of this decade many actions had already been taken which would have major impacts on important panther prey species. A remnant panther population centered within the Big Cypress region was verified, stimulating debate and research among individuals and agencies. At this time no intentional management for game species as panther prey was in effect. Deer, hog, armadillo and raccoon harvests were regulated by general statewide regulations and by specific management area regulations.

1980–1990. On the newly created BCNP, both hunting and possession of firearms were limited to established seasons. Only antlered deer could be taken and hunter quotas were established for the first nine days of the general gun season.

Major concerns expressed during the early part of this decade were the following: (1) too many hunters were allowed in the area; (2) improved access was increasing use of previously remote areas; (3) excessive harvest was adversely impacting prey populations, especially deer; (4) off-road vehicles (ORV's) and dogs significantly increased hunting harvest and efficiency; and (5) the combined length of all hunting seasons was excessive. One of the major concerns regarding season length and total pressure was that the presence of people in the woods with weapons would lead to excessive shooting mortality of panthers. Other concerns included the quality of deer habitat in the area, loss of habitat, oil exploration and extraction, and direct impacts on the panther. Highway mortality and biomedical concerns have been identified as issues with direct impacts on panthers. Table 1 summarizes the major changes in regulatory conditions from 1980–1990 and the intended prey management benefit. Most of these regulatory changes were designed to reduce harvest and/or hunting pressure.

Several prey management actions were also undertaken south of Alligator Alley (I–75). The first action was the exclusion of most private property in this area from the annual statewide doe season. This effectively placed all of the low density deer areas within panther habitat on a conservative ''buck only'' harvest since the BCNP was already closed to doe hunting. The second action was to recognize hogs as game animals. This afforded wild hogs limited protection by establishing hunting seasons, bag limits and size restrictions. The third action was the closure of the Fakahatchee Strand and adjacent lands to deer and hog hunting. The panther was the primary impetus for this significant change because deer numbers were low, and this area was considered a panther population center.

Table 1. Summary of major regulatory changes on Big Cypress National Preserve Area governing harvest of important panther prey species in southern Florida during the 1980s.

Initial regulation	New regulation	Intended or actual result
Off-road vehicles (ORV) must register, receive free NPS permit and meet minimum requirements.	ORVs must obtain annual $25 NPS permit.	Reduce the number of ORVs
ORVs allowed throughout the area except Loop Road unit and prohibition of airboats in Bear Island unit.	ORVs prohibited on 11-mile oil well road and any new oil access roads. Interim restriction enacted prohibiting use of 3- and 4-wheeled ATC type ORV's. Deep Lake closed to ORV's, ORVs in the Bear Island unit restricted to designated trails. All other units implement a combination of designated trails and designated areas.	Reduce hunting efficiency and limit access and impacts on remote areas.
Combined hunting season length including raccoon season of 270 days; general gun season of 58 days.	Combined hunting season reduced to 170 days including 49-day general gun season.	Reduce hunting pressure and harvest.

continued

Table 1. (continued).

Initial regulation	New regulation	Intended or actual result
Buck-only hunting "with polished antler visible above hairline."	Initially changed to a 1-inch antler rule and later changed to a 5-inch rule.	Provide better protection for the fawn age class and does.
Dogs allowed for deer and hog hunting except on Bear Island and Loop units.	Dogs restricted to first nine days of general gun and eventually totally prohibited.	Reduce hunter efficiency and harvest. Reduce potential disturbance to panthers.
Hunting pressure regulated by quota permits during first nine days of general gun season for all units and during the first nine days of muzzleloading season on Bear Island unit.	Quotas reduced on individual units and two additional quota periods implemented during peak holiday use periods.	Reduce hunting pressure and harvest.
Hunter access unlimited except Bear Island unit.	Hunter check-in/out mandatory. All game must be checked.	Improve measurement of harvest and use.
Deep Lake unit open during all seasons with all weapon types.		
Deep Lake unit designated archery-only with hunting allowed only during general gun season.		Reduce harvest and pressure.

The most significant land acquisition during 1980–90 was the purchase of the Florida Panther National Wildlife Refuge (FPNWR). This is the first property to be placed in public trust primarily for the benefit of the panther. This property also supports a panther population core.

Limited habitat management occurred on public land during the last decade. For the most part, these management programs have been limited due to budgetary and personnel constraints. The focus of habitat management has been the use of prescribed fire to provide improved conditions for prey species, especially deer. Recent burning programs on BCNP, FSSP and FPNWR should provide improved forage quantity and quality, and deer should respond positively to these programs if they are carried out on a long-term basis. However, habitat quality improvement is ultimately controlled by soil and hydrologic conditions that vary throughout the region.

Effects of Modern Management Strategies on Panther and Prey

The entire process of setting hunting regulations within the Big Cypress region has been designed to minimize or eliminate adverse impacts of sport hunting. Data gathered since 1980 tend to support these decisions although, in most cases it is difficult to establish a simple cause and effect relationship. We will attempt to address some specific proposals and present the entire relevant data set.

Early panther research suggested BCNP was an important population center for panthers (Belden 1986), so initial efforts at prey management for panthers began on this large preserve. Some agencies and individuals felt that excessive hunting pressure was either driving deer out of the area or resulting in excessive mortality and lower recruitment. Little data existed to substantiate these concerns but both GFC and NPS enacted a series of regulations designed to further minimize the potential impacts of recreational hunting. Table 2 summarizes hunting pressure and harvest on the 570,000 acre BCNP from 1983 to 1989.

Hunting pressure declined from 24,360 man-days in 1984 to 17,195 in 1985 following implementation of new regulations. Season length and the large land area has resulted in low hunter density. Under the BCNP quota system the maximum hunter density and harvest occurred on the Bear Island unit (one hunter per 60 ha and one deer harvested per 400 ha). On a daily basis there are usually between 50 and 500 hunters on the entire BCNP. Hunter density ranges from 450–4,600 ha per hunter.

Hunting can be the primary form of disturbance for deer, especially in heavily hunted areas (Tester and Heezen 1965, Robinette 1966, Downing et al. 1969). However, Marshall and Whittington (1969) found that one hunter per four ha did not cause deer to leave their home range. Radiotelemetry studies of 44 deer in BI have failed to detect any significant shifts in home range associated with hunting season. The arithmetic centers of deer home ranges varied an average of 300 ± 366 m between hunting and non-hunting intervals. These 44 deer have been instrumented for an average of two hunting seasons and 42 of these animals maintained use areas entirely within BI. The two remaining deer, both does, were captured along the area boundary and consistently used areas inside and outside of BI. Panthers, on the other hand, utilize much larger areas and routinely move distances up to 20 km overnight (Maehr 1990b). Monthly analyses of radio-telemetry data indicated that panthers used BI less during winter months than any other time of the year. Human activities

Table 2. Big Cypress National Preserve deer harvest, hog harvest and hunting pressure, 1983–1989.

Year	Hunting man-days	Deer harvest	Hog harvest	Hunter success
1983	23,015	140	201	0.015
1984	24,360	205	195	0.016
1985	17,195	156	111	0.016
1986	17,290	127	153	0.016
1987	17,525	208	138	0.020
1988	21,570	185	144	0.015
1989	21,660	186	154	0.016

associated with hunting have been considered as a possible explanation for lower than expected use by panthers in this most popular unit of BCNP (Maehr 1990b).

Illegal hunting and crippling losses may have a negative impact on local deer populations. However, radiotelemetry data from Bear Island indicate that this has not been a problem (Land 1990). Seventeen radio-instrumented deer died during a three-year period beginning in 1986. Two were taken illegally; bobcats (*Lynx rufus*) and Florida panthers killed five and four deer respectively. Survival rates were calculated on both a seasonal and annual basis following Heisey and Fuller (1985). The average annual survival was 78.0 ± 7.8 percent.

The apparent low rate of illegal harvest and crippling loss also was reflected in harvests following implementation of the five-inch antler rule. In the first season under this rule, deer harvest declined 18.6 percent to 127 animals. In the second season, deer harvest increased to 208 animals. This indicates good survival especially of yearling bucks with antlers less than five inches in 1986.

Post-rut "buck only" hunting is generally considered a conservative harvest strategy which minimizes harvest and reduces impacts on reproduction (McCullough, 1984). These hunts generally remove less than 10 percent of the total population (Loveless 1959, Harlow and Jones 1965, Hesselton and Hesselton 1982).

Checked harvest on BCNP has never exceeded 208 deer for the entire area. This represents a harvest rate of one deer per 1,100 ha. While the total harvest exceeds the checked harvest we believe that harvest rates rarely exceed the one deer per 400 ha found on BI where most deer are checked. The age class structure also indicates moderate hunting pressure. From 1983 to 1989, yearlings and 2.5 year old bucks accounted for 78 percent of the harvest (41 percent and 35 percent respectively). Older bucks accounted for 24 percent of the harvest. In heavily hunted herds, it is not unusual for yearlings to comprise 70 percent of the buck harvest.

The implementation of a five-inch minimum antler regulation on the BCNP significantly changed the age structure of harvested bucks (x^2-test, $p = 0.005$) (Table 3). Harvested deer were classified by age and then summarized into three-year averages under the one-inch minimum antler regulation (1983–85) and the five-inch antler regulation (1987–89). A transitional year (1986) when the five-inch minimum regulation was first enacted was treated separately. The initial response to the five-inch antler rule was the elimination of fawns in the checked harvest and a reduction

Table 3. Age structure of male white-tailed deer harvested from the Big Cypress National Preserve before and after the implementation of the five-inch minimum antler regulation.

	One-inch antler		Five-inch antler			
	1983–1985 (3-year average)		1986 (transitional)		1987–1989 (3-year average)	
Age Class	Percentage	N	Percentage	N	Percentage	N
0.5	6.7	21	0.0	0	0.0	0
1.5	46.6	146	44.6	33	27.4	118
2.5	29.1	91	29.7	22	44.3	191
3.5	9.9	31	14.9	11	20.2	87
4.5+	7.7	24	10.8	8	8.1	35
N		313		74		431

of the total number of bucks harvested. In subsequent years (1987–89), yearlings (1.5 year-olds) were substantially reduced in the harvest while older bucks increased. The age structure of harvested bucks shifted to older age classes as predicted under the new regulation.

Does collected for study during the 1984–86 period exhibited a somewhat older age structure. Yearlings and 2.5 year old does accounted for 57 percent of all deer collected (21 percent and 36 percent respectively). Does 3.5 years old accounted for 18 percent, while older animals (4.5 years and older) accounted for 25 percent of the sample.

Significant differences in female body weights, APCs, in-utero fecundity, and concentrations of ruminant diaminopimelic acid (a forage quality indicator) suggests that BI deer habitat is superior to that of CD (McCown 1988). Comparisons with other deer herds in the southeast (Eve and Kellogg 1977, Stockle et al. 1978, Labisky and Richter 1981) suggest that BI provides only moderate quality deer habitat.

Does examined within BCNP had pregnancy rates exceeding 90 percent and a mean conception date of August 12. Sixty-five percent of the does were bred within a 30-day period and 90 percent were bred before the start of hunting. Antlered to antlerless deer ratios were approximately 1:3 in 568 observations. Clearly, post-rut bucks-only hunting did not adversely impact reproduction on BCNP.

Harlow (1959) classified major deer habitats in Florida and estimated carrying capacity. In the Big Cypress area, CD is a mixture of swamp and flatwood habitats with a potential maximum density of one deer per 45 ha. The eastern Stairsteps unit (SS) is primarily freshwater marsh with a potential density of one deer per 35 ha. BI is significantly better deer habitat. It consists of a mosaic of these three habitat types with a much higher density of interspersed hammocks. Hammocks alone have a potential density of one deer per 6 ha. We estimate the potential density of all BI habitats combined to be one deer per 20 ha under present management practices.

Actual deer densities were estimated for these three units of BCNP. Track counts were conducted on BI and CD while aerial surveys were utilized in the open sawgrass-marsh habitat in SS. Deer densities were greatest in BI (one deer per 20–40 ha); estimates in CD ranged from one deer per 65–100 ha; and estimates in SS ranged from one deer per 30–100 ha.

The Big Cypress deer herd is apparently being maintained at or slightly below estimated potential densities. Poor recruitment in high rainfall years, predation and poor productivity on low quality habitats may be preventing catastrophic die-offs such as those recorded periodically in the adjacent Everglades area (Schortemeyer 1980).

Conclusions

Many of the important prey management actions occurred before the welfare of the Florida panther was a concern. Two important prey species are exotics which became established as a result of actions unrelated to Florida panthers. Both wild hogs and armadillos are well established in most currently occupied panther range. Efforts to control or eliminate either species from currently occupied range could have adverse impacts on the panther. In addition, stocking, especially wild hogs, could enhance game abundance, especially in areas where low prey density has been identified as a problem for the panther.

The most important action to date has been the protection of over 1,000,000 ha of contiguous landscape in the Everglades/Big Cypress areas. Most of this land is not prime habitat for the panther or its prey (Maehr 1990a), and many areas are marginal at best. Nevertheless, there is little question that this large protected area greatly enhances the prospect for successful panther management.

Conversely, the loss of habitat due to urban and agricultural development has been widespread. As these losses continue, new management strategies and incentives must be developed to insure that private lands will continue to provide important habitat for panther and their prey. Without effective conservation programs on private lands in southern Florida, the less productive lands in public ownership will be forced to provide a greater proportion of the panther's range.

Data-based prey management actions were initiated in southern Florida only in the last decade. Initially, management was regulatory and aimed at minimizing perceived adverse impacts of recreational hunting on both prey and predator. These actions combined with the existing conservative bucks-only harvest strategy have been successful in minimizing the potential adverse impacts of overharvesting deer and hog. Examination of deer herd parameters indicate that productivity and populations are within desirable limits considering the quality of habitat.

Higher prey densities may be achieved by improving habitat conditions. Increasing forage quantity and quality is the management option which has the greatest potential in the Big Cypress area. The use of prescribed fire is currently being utilized by most land management agencies primarily to prevent catastrophic wildfires by reducing fuel levels. Only recently have managers of these public lands recognized the potential for improving habitat conditions for wildlife via prescribed fire. In order to provide maximum benefits for deer and other important prey species, burning programs should be designed for these specific purposes. Burns should be conducted on fire tolerant areas on a two- to five-year rotation, depending upon fuel type and site conditions. Burn compartments should be less than 2,500 ha and annual partial compartment burns or rotating burns should be employed when possible to increase habitat heterogeneity.

Other habitat management actions may also provide significant benefits for deer and/or hogs. Food plots, clearings and feeders have been effective management tools in local situations. Disturbed sites, particularly those invaded by willows, have produced good forage for deer. Establishment of mast producing species, including oak and palms, on disturbed sites can significantly increase mast production in selected areas.

While the present conservative harvest strategy has been effective in maximizing deer numbers, wildlife managers need to retain flexibility in meeting tomorrow's challenges. Changing environmental conditions may lead to excessive fluctuations in prey populations. Increased harvest, including either sex hunts or conversely more conservative strategies, may be needed to provide sustained maximum benefits for panthers and their prey.

Current information shows that recreational hunting does not adversely impact deer behavior or deer numbers. However, telemetry data indicates that panthers may be altering use patterns in response to human activity related to hunting seasons. Recent regulation changes including designated trails, reduced quotas and shortened seasons may reduce these impacts. However, because the cause and effect relationships between panther and human behaviors have not been established, additional research concerning predator, prey and human interactions would be valuable.

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Management of Predators and Their Prey: The Alaskan Experience

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Introduction

Since 1970 biologists have studied the relationships between large predators and ungulate prey. These efforts in Alaska have centered on relationships of gray wolves (*Canis lupus*) and bears (*Ursus arctos* and *U. americanus*), with their principal ungulate prey, moose (*Alces alces*) and caribou (*Rangifer tarandus*). Management of predators has been controversial among some segments of the public, resulting in intense public scrutiny of many control programs (Harbo and Dean 1983). Between 1975 and 1991, agency sponsored wolf and bear control programs, aimed at increasing moose and caribou populations, were initiated in eight of Alaska's 26 game management units (GMUs). Currently, no agency is conducting predator control programs in Alaska. I review moose and caribou data that caused wildlife managers to conclude that predator reduction programs were needed. Methods used to assess status of predators and prey are described; the magnitude and length of time predator control was necessary are reviewed; and benefits to prey, predators and humans are examined. I limited this review of Alaskan predator-prey programs to four research studies for two reasons: (1) the data base was insufficient to evaluate fully the need for and merits of predator control activities in other areas; and/or (2) the degree of predator removal was not sufficient to expect a large response by prey populations.

Methods

Relative abundance and trends in sex and age composition of moose in Alaska were evaluated annually in late autumn following fresh snowfall, early winter, or late winter through surveys conducted from fixed-wing aircraft within established trend count areas (Gasaway et al. 1986, Ballard et al. 1991). Survey intensity typically averaged about 1.0 minute per square mile (0.4 min/km^2). Moose observed per hour of survey were used as an index of abundance, calves per 100 cows were used as indices of recruitment, bull per 100 cow ratios were used as indices of sex ratios, and percentage of yearling bulls were used as indices of yearling recruitment (Ballard et al. 1991). When precise estimates of moose abundance and density were desired, stratified random sampling was used with fixed-wing survey intensities $\geq$4.0 minutes per square mile (1.5 min/km^2) (Gasaway et al. 1986). Frequency of such estimates was dependent upon study objectives and funding.

Caribou population estimates were made for each major herd every 2–5 years using the aerial photo-direct count extrapolation method (Davis et al. 1979). Recruitment was usually estimated from composition surveys conducted in late autumn.

Wolf population estimates were obtained by counting individual wolves and/or their tracks from fixed-wing aircraft during December through April, following fresh snowfall (Stephenson 1978). During portions of studies discussed in this review, numbers of known wolves in radio-marked packs were used to obtain density estimates that were extrapolated to areas of management significance (Ballard et al. 1987). For predator control programs, wolves were killed by aerial shooting from helicopter or fixed-wing aircraft, usually during late winter.

Estimates of grizzly and black bear populations were estimated by extrapolation from estimates provided in the literature and adjacent areas or by modified mark-recapture procedures which used radio telemetry to assess population closure by procedures described by Miller et al. (1987). Bear populations were not subjected to lethal agency control programs. Instead, bear populations were reduced by temporarily transplanting bears away from an area (Miller and Ballard 1982a, 1982b) or through increased sport harvests (Miller 1990, Ballard and Miller 1991).

Human harvests of predators and ungulates were determined by mandatory hunter reports or check-in. Moose and caribou hunters were required to report regardless of success, but compliance was less than 90 percent; nonresponse bias was not measured. Only successful bear and wolf hunters were required to report, and compliance was greater than 90 percent in areas where predator control was conducted.

Causes of calf and adult moose deaths were determined using methods described by Ballard et al. (1979) and Stephenson and Johnson (1972, 1973). Mortality rates of radio-collared individuals were assessed using methods described by Gasaway et al. (1983), White (1983), and Pollock et al. (1989). Physical status, age structure and pregnancy rates of ungulate populations were assessed from immobilized animals using blood and physical measurements (Franzmann and LeResche 1978), aging incisor teeth (Sergeant and Pimlott 1959), and rectal palpation (Roberts 1971), respectively. Relationship of ungulate populations to habitat was assessed through twinning rates (Franzmann and Schwartz 1985), physiological condition based on blood values (Franzmann et al. 1987), or general vegetative surveys (Lieb et al. 1984, Tobey 1989a). Physical condition of dead ungulates was assessed by direct physical examination and marrow fat values (Neiland 1970). Productivity and twinning rates were determined by frequent observation of radio-collared individuals from fixed-wing aircraft (Ballard et al. 1981, 1991). Winter severity was assessed based on combinations of U.S. Soil Conservation Service snow survey data and snow depths recorded at National Weather Service stations (Gasaway et al. 1983, Ballard et al. 1991).

Historical Overview

Moose, caribou, wolves and bears have existed in Alaska for thousands of years (LeResche et al. 1974). Populations of these species have fluctuated widely over time. Fluctuations since 1970 were better documented than in previous years. Over most portions of Alaska, moose and caribou populations increased in the 1940s and 1950s due to favorable range conditions created by wildfires, relatively mild winter conditions, bull-only hunting prior to 1950, and predator control in the 1950s (Skoog 1968, Bishop and Rausch 1974). Wolf and bear populations were severely reduced over large areas, and some wolf populations were driven to near extinction by poisoning and aerial shooting in the 1950s (Rausch 1967, 1969). During the 1960s, moose and caribou populations in most of the state began to decline due to a combination of severe winters, excessive human harvests and predation. Predator populations quickly increased following cessation of federal predator control activities in the 1950s. Predation was thought to be a major contributing factor to the ungulate declines. Human harvests were also a large contributing factor which accelerated declines. By the mid-1970s, many ungulate populations had declined to relatively low levels while predator populations, particularly wolves, increased to high levels. The apparent inverse relationship between wolf and ungulate populations caused some biologists to suspect that wolf predation was limiting ungulate population growth. As a result, several wolf control programs were initiated in the mid-1970s (Harbo and Dean 1983). The following case histories are representative of the conditions and actions taken by the Alaska Department of Fish and Game (ADFG), and provide the basis for the ensuing discussion concerning the conduct of control programs.

Case Histories

Tanana Flats. Moose and caribou populations increased during the 1950s and reached peak numbers in the early to mid-1960s (Gasaway et al. 1983). Deep snows in 1965–66 caused a large moose die-off, and the population began to decline. The caribou population began to decline about 1970. Several severe winters occurred in the early 1970s, and moose and caribou populations continued to decline. During the declines, human harvests continued with peak harvests in 1970–74 (Gasaway et al. 1983). Human harvests accelerated the decline. Wolves were reportedly abundant in the early 1950s, although precise estimates were not available. A wolf control program was conducted by the federal government from 1954–60 (Gasaway et al. 1983). During the 1960s, the wolf population increased, and peak numbers were reached in the late 1960s and early 1970s, at the same time moose and caribou populations were declining. Decline of the moose herd was attributed to the interaction of periodic deep snows, harvest by man and wolf predation, while declines in the caribou herd were attributed to human harvest and wolf predation (Gasaway et al. 1983). Predation by wolves was estimated to have killed from 13 to 34 percent of the moose population during winters 1973–74 and 1974–75. Significant losses of calf moose during summer were also attributed to wolf predation. The moose population reached a record low of about 2,800 (52 per 100 square miles: 200/1,000 km^2) by 1975. Predation by bears was not considered a significant source of mortality to moose or caribou at that time on the Tanana Flats.

Wolf population reduction efforts were initiated in 1976 and continued through 1981–82 (Gasaway et al. 1983). During control efforts, wolf populations were reduced by 38–61 percent annually. While control was in effect, the moose population increased; calf and yearling moose survival improved two- to four-fold, and adult moose mortality was reduced from 20 to 6 percent annually. Moose numbers increased from about 2,800 in 1975 to more than 5,000 by 1982 and currently numbers between 8,00–10,000 (McNay 1989a). Between 1978 and 1984, moose densities increased by 14–15 percent annually. Caribou populations also increased from about 2,000 in 1976 to 6,500–7,500 by 1982.

Following termination of wolf control activities in 1982, wolf numbers increased to 180–220 wolves by autumn 1983. Wolf numbers stabilized at about 195 from 1985–87 and are slowly increasing (McNay 1989b).

As ungulate populations recovered, human harvests slowly increased. During the early stages of wolf removal (1975–78), moose harvests were restricted ($\bar{x}$ = 64 bulls/year). Since 1978, moose harvests have been progressively liberalized; during 1979–82 and 1983–87, an average of 226 and 374 bulls, respectively have been harvested annually. Recent harvest rates are about 4 percent of the pre-hunt population, and range use by moose was still light (McNay 1989a). Caribou harvests were prohibited during 1974–79. Harvests were gradually liberalized in the 1980s and currently average about 500 annually. Reduced numbers of wolves during 1976 through 1982 allowed moose and caribou populations to increase. Human harvests also increased and predator populations returned to near pre-control levels.

Nelchina Basin. Bishop and Rausch (1974), Ballard et al. (1987, 1991), and Bergerud and Ballard (1988, 1989) provide through historical reviews of moose and caribou populations in the Nelchina Basin. Similar to the Tanana Flats example, moose and caribou populations in the Nelchina Basin increased in the 1950s and early 1960s. Increases were attributed to favorable range conditions, relatively low human harvests, relatively mild winters and relatively low numbers of predators. Federal wolf control programs that included poisoning and aerial shooting during 1948–54 reduced the wolf population to approximately 12 by 1952 (Rausch 1967, 1969). Because poison was used, many bears may also have died. Wolf and bear populations were declining or were present at very low densities while moose and caribou populations were increasing (Bishop and Rausch 1974; Ballard et al. 1987, 1991).

Wolf control formally ended in 1954, but few wolves were killed after 1952. After 1952, the wolf population began to increase. Rausch (1967, 1969) reviewed the history of wolves in the Nelchina Basin and concluded that the wolf population increased slowly and reached peak numbers of 350–450 wolves by 1965. The population then declined to about 300 by December 1967 partly due to illegal aerial hunting activities. Rausch (1967, 1969) included portions of GMU 11 in his estimates and provided two different estimates for the same population in two different publications: 350–400 wolves (1967) and 400–450 wolves (1969). Van Ballenberghe (1981, 1985) used these discrepancies to discount Rausch's estimates and subsequently revised all but one of the wolf population estimates made by several investigators between 1953–67. Bergerud and Ballard (1988, 1989) questioned the validity of Van Ballenberghe's (1981, 1985, 1989) revised estimates and recommended against their use because the earlier estimates had no statistical variance; subsequent revisions without the benefit of original data and expertise of the investigators were unwarranted and could be inaccurate. Wolf densities peaked at 2.7 per 100 square miles (10.3:1,000 km^2) in 1975 and declined through 1982 due to ADFG control programs and increased public harvests (Ballard et al. 1987). Spring wolf densities after 1983 gradually increased through 1986 (W. B. Ballard personal files: 1990), may have declined slightly during 1987–89 (Tobey 1989b), but by 1990 reached the highest spring density ever recorded for GMU 13 (i.e., 2.3–6.2 per 100 square miles: [9–24 wolves/1,000 km^2 [Becker and Gardner 1991]).

As wolf populations were increasing, moose and caribou populations began declining (Bishop and Rausch 1974). Moose peaked in the early 1960s and, after several severe winters, declined precipitously to record low numbers by 1975 when the wolf population peaked (Ballard et al. 1987, 1991). The moose decline was thought to have been triggered by severe winters, but the decline was accelerated by human harvest and predation. The caribou herd in the Nelchina Basin declined from about 70,000 in 1962 to about 8,000–10,000 by 1972 (Van Ballenberghe 1985, Bergerud and Ballard 1988). Hunting played a major role in the decline of the herd during this period, but the roles of winter severity versus predation by wolves has been debated extensively (Van Ballenberghe 1985, 1989; Bergerud and Ballard 1988, 1989).

Because of the apparent inverse relationship between wolf and ungulate prey numbers and a high incidence of calf moose hair in wolf scats (Stephenson and Johnson 1972, 1973, Bishop and Rausch 1974, Bergerud and Ballard 1988, 1989, Ballard et al. 1987, 1991), wolves were experimentally reduced during 1976–78 within the 2,803 square mile (7,262 km^2) Susitna River Study Area (SRSA). Wolves were annually reduced by 42–58 percent (Ballard et al. 1987). Although reductions in wolf numbers improved moose calf survival enough to allow the moose population to annually increase by 3–6 percent (Ballard et al. 1984, 1986, 1991), the increases were substantially less than those reported by Gasaway et al. (1983) in interior Alaska. In retrospect, moose/wolf ratios were substantially greater in the Nelchina Basin than in interior Alaska and so a lesser response would have been expected. Regardless, the lower results caused biologists to pursue determining the causes of moose calf mortality directly.

During 1977 and 1978, 120 neonatal moose calves were captured and radio-collared (Ballard et al. 1979). About 55–60 percent of the calves died annually, but 79 percent of the deaths were due to predation by brown bears (Ballard et al. 1981); 3 percent were due to wolf predation. Sixty percent of the brown bears within a 1,326 square mile (3,436 km^2) areas were temporarily translocated from the area in 1979 (Miller and Ballard 1982a, 1982b). Bear densities were estimated at 6.2 per 100 square miles (24/1,000 km^2) prior to removal. Moose calf survival increased significantly ($P < 0.05$) from 34 calves per 100 cows before bear removal to 58 calves per 100 cows immediately after bear removal (Ballard and Miller 1990). There was no improvement in comparative areas where bear densities were not manipulated.

Within one denning season after termination of control, wolf densities recovered within 81 percent of precontrol levels, and exceeded those in the remainder of the unit after two denning seasons (Ballard et al. 1987). Ballard et al. (1991) concluded that the moose population increased after 1975 due to combined effects of mild winters, reduced human harvests and reduced numbers of predators. Likewise, the caribou herd in the Nelchina Basin also increased in the mid–1970s and 1980s from a low of about 8,000 to 40,000 by 1989 (K. Pitcher personal communication: 1990). The increase was likely a result of the same factors that allowed moose populations to increase (Van Ballenberghe 1985, Bergerud and Ballard 1988, 1989).

Beginning in 1980, grizzly bear hunting seasons were greatly liberalized in GMU 13 (Miller 1990) in an effort to reduce bear numbers and increase the moose population. Unfortunately, there were no designed studies in place to evaluate the effects of this strategy on bears, wolves or moose. Bear populations were reduced by about 36 percent over seven years (Ballard and Miller 1991). Ballard and Miller (1991) used autumn moose sex and age composition surveys to evaluate the effects of the bear reduction program. While the bear reduction was in progress, wolf populations increased. Ballard and Miller (1991) concluded that the moose population had increased for five years prior to liberalization of bear hunting seasons, and in retrospect, bear population reduction was unnecessary to allow moose population growth. Moose calf survival apparently did not increase in the 1980s like it had in 1979 following the bear translocation experiment. By the time the bear population had been reduced, the moose population had grown considerably since the transplant experiment (Ballard et al. 1991), and calf moose mortality had become more compensatory and less additive. Increased predation rates by the remaining bears, or increases in predation by a growing wolf population, may also have been responsible for lack of response. All of the above explanations could have been correct to some degree (Ballard and Miller 1991).

During the 1970s and 1980s, moose hunting regulations were restricted to bulls-only during relatively short seasons (i.e., 20 days). However, moose harvests increased from about 700 bulls in 1976 to 1,140 bulls in 1986. An increasingly larger proportion of the GMU's annual moose harvest came from the SRSA suggesting that the increased moose calf survival due to reduced predator numbers in the mid-1970s resulted in larger moose harvests (W. B. Ballard, unpublished data). Human harvests of caribou were also tightly controlled after 1976. Caribou hunting was by permit only and annual harvests gradually increased from about 360 in 1977 to about 1,200 in 1989.

East-central Alaska. Moose populations in east-central Alaska irrupted during the 1950s and early 1960s, and then rapidly declined (Gasaway et al. 1990a). Severe winter weather and overharvest apparently did not trigger or cause the decline (Gasaway et al. 1990a). The caribou population declined between 1963–73 due to wolf predation and excessive human harvest (Davis it al. 1978). Wolves also declined in the mid-1970s after prey became scarce.

During 1981 through 1983, wolf populations within a 5,984 square mile (15,500 km^2) experimental area were annually reduced by 28–58 percent due to wolf control and public harvests. Wolf control had no measurable effect on calf moose survival (Gasaway et al. 1990a). Predation by grizzly bears was the largest source of moose calf mortality and an important source of adult moose mortality (Boertje et al. 1988).

Human harvests had little impact on ungulate populations during 1976–88 (Gasaway et al. 1990a). Moose hunting seasons were closed during 1977–81 and only bulls were taken during the 1980s, which accounted for 2 percent of the total annual mortality. Caribou harvest rates during the same period averaged 2 percent (Valkenburg and Davis 1989). During 1973 through 1988, the caribou population increased and was a moderate source of alternate prey for wolves (33 percent of wolf diet was composed of caribou) and bears.

Predation from bears and wolves was the largest cause of moose mortality (i.e., 31 percent of the moose population killed by predators annually) in their low density moose population (Gasaway et al. 1990a). Wolf control had little impact because of its light intensity (i.e., only in two years were harvest rates sufficient to cause a wolf population decline) and the wolf population was stable at reduced size through 1988–89. Bear populations were relatively high (4.1 per 100 square miles: 16/1,000 km^2) and lightly exploited. Gasaway et al. (1990a) concluded that over portions of central and east-central Alaska and the Yukon Territory, bear and wolf predation were limiting moose populations at low density well below habitat carrying capacity.

Kenai Peninsula. Although predator populations on the Kenai Peninsula were not manipulated by agency control programs, I choose to include the area in this discussion because of the lesson it provides concerning high density moose populations in relation to abundant high quality moose habitat with three predator species present.

Historical moose population fluctuations on the Kenai Peninsula were similar to those of interior Alaska with two exceptions: wolves were absent from 1915 to 1960, and the moose population continued to grow until 1970–71 because of habitat created by wildfire (Bishop and Rausch 1974). Moose populations in 1947 and 1969 burns peaked in 1971 and 1984, respectively. Severe winters caused extensive calf moose mortality in the early 1970s, and wolf populations, although limited by human harvest, increased to densities of 11–20 per 1,000 km^2 (Peterson et al. 1984). Hunting of cow moose in the early 1970s accelerated the decline in some areas (Schwartz and Franzmann 1989). Harvests of bull moose peaked at 573 in 1964. During 1975 through 1987, harvests ranged from 100–280 bulls annually. Black bear densities ranged from approximately 200–260 per 1,000 km^2, while grizzly bear densities were relatively low at 12–28 per 1,000 km^2 (Schwartz and Franzmann 1991).

Franzmann and Schwartz (1986) and Schwartz and Franzmann (1989, 1991), using mortality sensing radio collars, compared causes of moose calf mortality between the 1947 and 1969 burn areas. Black bears killed 34 and 35 percent of the calves, respectively, while wolves and brown bears combined killed between 5–13 percent of the calves. Total calf mortality before winter from all causes averaged 51–55 percent. Moose densities were four times greater in the 1969 burn (i.e., 959 per 100 square miles: 3,700/1,000 km^2) than in the 1947 burn (259 per 100 square miles: 1,000/1,000 km^2), and the moose population was increasing during their studies (Schwartz and Franzmann 1991). Conversely, in the 1947 burn, moose densities were 80 percent lower than those in the 1969 burn, and the population was declining. Moose in the 1969 burn also were much more productive than those in the 1947 (Franzmann and Schwartz 1985).

Schwartz and Franzmann (1989) speculated that predation influenced the rate of change and absolute densities of moose. After habitat improvement, the rate of increase of a moose population is retarded, and peak densities lower when predator populations are near carrying capacity. Following a moose population peak, the rate of decline is greater and densities lower in areas where predators are near carrying capacity. The exact opposite is true in near predator-free environments. When moose populations approach or exceed habitat carrying capacity, reductions in predator numbers are likely to have no effect on moose population growth because such mortality would probably be compensatory (McCullough 1979, 1984).

Discussion

All declines of ungulate populations in Alaska occurred as a result of some combination of severe winters, excessive human harvests and predation (Ballard and Larsen 1987), except in east-central Alaska where predation alone may have caused ungulate population declines (Gasaway et al. 1990a). When mild weather conditions returned, many ungulate populations continued to decline. Managers originally thought that ungulate populations had exceeded habitat carrying capacity and declined as a result. However, most indicators suggested that available habitats were understocked. Human harvests were severely restricted or curtailed, but these actions had little noticeable impact on abundance or recruitment indices.

Studies of radio-collared adults indicated that initial productivity following population declines was high in most populations (Ballard et al. 1991, Davis et al. 1978, Gasaway et al. 1990a). Large numbers of moose calves were being born, but from 52–83 percent died within the first six weeks of life (Franzmann et al. 1980, Ballard et al. 1981, Boertje et al. 1987). When biologists radio-collared moose calves, they were able to directly determine that predation by brown bears, black bears or wolves was capable of producing the observed mortality patterns.

Limitations on ungulate populations due to wolf predation were easier to detect than those caused by bears. Comparisons of ungulate/wolf ratios can provide managers with a quick indication if wolf predation is likely to limit an ungulate population. Gasaway et al. (1983) summarized this concept as follows: (1) at ratios of less than <20 moose per wolf, predation usually is sufficient to cause a decline in abundance and low survival of calves and adults; (2) at 20–30 moose/wolf, predation can be the primary factor controlling numbers of moose; and (3) at ratios more than moose per wolf, predation can be significant but not necessarily limit population growth. Although this guidelines was aimed largely at simple moose-wolf systems, it may also apply in multi-predator-prey systems where moose are primary (>70 percent) prey of wolves. Caution must be used because these ratios do not account for changing prey availability and vulnerability, surplus killing, prey age structures, changing predation rates that may vary several-fold, and vegetation-ungulate relationships (Gasaway et al. 1983, Ballard and Larsen 1987). They also do not account for predation by bears which was an important mortality factor in many Alaskan studies (Franzmann et al. 1980, Ballard et al. 1981, Boertje et al. 1987).

Detection of bears as a major cause of ungulate mortality required use of mortality-sensing radio collars. Once identified, determining actual bear density and sex and age structure was difficult and expensive. Recently, mark-recapture techniques using radio-collared bears to assess population closure has allowed managers to quickly assess bear densities with some degree of confidence (Miller et al. 1987). However, the method is expensive and has been used only in areas ≤714 square miles (1,850 km^2) (Ballard et al. 1990a). Once bears have been identified as a significant source of mortality, formulating a desirable plan to cope with the problem is a dilemma. Grizzly bears are usually the largest source of moose calf mortality when bear densities ≥4.1 per 100 square miles (16:1,000 km^2) (Ballard 1992). Brown bear predation rates appear to be independent of moose density (Boertje et al. 1988, Ballard et al. 1990b), while black bear predation rates and moose density are positively correlated (Ballard 1992).

Ballard and Miller (1990) demonstrated that a temporary 60 percent reduction in grizzly bear density was sufficient to significantly ($P < 0.05$) improve moose calf survival for one year. Whether lesser temporary or permanent reductions in bear numbers would be sufficient to increase moose calf survival proportionately is not known (Ballard and Larsen 1987, Ballard and Miller 1990). A recent 36 percent reduction in grizzly bear density in a portion of south-central Alaska was deliberately caused by sport hunting. The effort apparently did not improve moose calf survival (Ballard and Miller 1991). Several explanations for the lack of response were possible: (1) the moose population was close enough to habitat carrying capacity so that bear caused mortality was now more compensatory than additive as it had been earlier; and/or (2) increased numbers of wolves compensate for the reduced predation by bears (Ballard and Miller 1991). Because it has not yet been demonstrated that hunting induced reductions in bear numbers result in increased moose calf survival, Ballard and Miller (1991) cautioned managers against routinely lowering bear densities to increase moose calf survival. Tightly designed research programs examining such mortality in relationship to habitat utilization and wolf predation are necessary for managers to reliably manipulate bear populations to favor ungulates. However, great caution must be exercised in deliberately lowering bear numbers to favor ungulates because grizzly bears have low reproductive rates and changes in bear numbers are difficult to detect (Peek et al. 1987, Ballard and Larsen 1987, Miller 1990, Ballard and Miller 1991).

Reductions in wolf numbers for three to five years have resulted in increases in ungulate populations in areas where wolves were a large cause of ungulate mortality and where control resulted in ≥50 percent reduction of the wolf population. In areas where brown bears were the largest cause of moose calf mortality but moose densities were relatively high (i.e., >130 per 100 square miles: 500/1,000 km^2), reductions in wolf numbers, without reducing bear numbers, were sufficient to allow the moose population to increase (Ballard et al. 1984, Ballard and Miller 1991). Temporary translocation of brown bears can also be effective at increasing ungulate survival in small areas. Continually striving to improve moose habitat to help keep moose densities, over-winter survival and productivity high, such as on the Kenai Peninsula, (Schwartz and Franzmann 1989) can augment and, in some cases, reduce the need for predator programs so long as ungulates have not declined to low levels. Close monitoring of human harvests, particularly in relation to severe winters, is essential if large-scale declines are to be avoided. However, in some areas of Alaska, where ungulate populations have not yet escaped the constraints of predation, even harsher measures may be necessary.

Ungulate populations in large areas of interior Alaska and Yukon Territory are currently maintained at low densities due to combined predation by wolves, grizzly bears and black bears (Gasaway et al. 1990a). Without large reductions in at least two of the three predator species and tightly controlled human harvests, it is unlikely that any of these ungulate populations will increase or escape the "predator pit" (Ballard and Larsen 1987, Gasaway et al. 1990a). Moose densities in these latter areas averaged only 4 per 100 square miles (155/1,000 km^2, range = 12–108 per 100 square miles:45–417/1,000 km^2) (Gasaway et al. 1990a). Without a reduction in predator numbers, human uses should be drastically restricted, and relatively long periods of ungulate scarcity should be expected until some phenomenon occurs which allows ungulates to escape constraints of predation. Because bears are not obligate carnivores, feed-back mechanisms between ungulate and bear population size may be slow or nonexistent (Ballard and Larsen 1987).

Gasaway et al. (1990a) concluded that high density moose populations in Alaska were the products of predator management. Moose attained relatively high densities (130–259 per 100 square miles [500–1,000/1,000 km^2]) only in areas where bears and wolves were exploited below carrying capacities. Where wolves and bears were lightly exploited, ungulates were held at low density equilibriums.

Lethal management of predators to increase ungulate populations has been largely successful in elevating ungulate densities in several situations in Alaska, but such programs have been controversial and divisive among many members of society (Harbo and Dean 1983). Wildlife managers have been caught between two extreme advocate groups: one group objects to all forms of predator management, while the other prefers severe reduction or elimination of all predators to favor ungulates. In an effort to reduce public confrontations over predator management and gain more representation of the public's desires, ADFG recently initiated a citizens' wolf management planning team. Composed of members of primary user and advocacy groups, the team's primary function is to provide recommendations for a statewide wolf management plan.

Predator control is but one tool of wildlife management (Leopold 1933) that in some circumstances could help reduce or eliminate long periods of ungulate scarcity that has historically occurred in Alaska. ADFG is also investigating several nonlethal methods of predator control, such as increasing alternate prey and diversionary feeding, but results are inconclusive to date (Bortje et al. 1990, Gasaway et al. 1990b). Biologists should conduct research programs and attempt to advise the public of facts and biological probabilities, but informed decision-makers with appropriate public input must ultimately decide how wildlife is to be managed.

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Managing Wolf and Ungulate Populations in an International Ecosystem

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Introduction

Wolves (*Canis lupus*) in the inter-mountain West were systematically eliminated by the late 1930s in the United States and severely reduced in southern British Columbia and Alberta. Trapping, poisoning, shooting and even an attempt to introduce mange into the Montana population shortly after the turn of the century were used to achieve this desired result (Day 1981). Bears, both grizzly (*Ursus arctos horribilis*) and black (*U. americanus*), mountain lions (*Felis concolor*), coyotes (*Canis latrans*), and most other carnivores were also persecuted. This wide-spread predator control affected most carnivore populations into the mid-20th century. Ungulate populations crashed through the turn of the century due to unregulated human harvest (Trefethen 1975), but then exploded concomitant with strict game laws, habitat changes, and the virtual elimination of large predators. High elk (*Cervus elaphus*) populations in the 1940s through 1950s encouraged Fish and Game Departments to suggest the construction of new roads into previously unroaded country to increase hunter access and harvests of these herds (Mohler et al. 1958). Reductions of ungulates in national parks also occurred during this period (e.g., Houston 1982).

Human attitudes toward predators (Curnow 1969) and increased human access precluded any significant recovery of large predators. Wolves were absent, other than an occasional disperser, in the western United States through the 1970s (Singer 1979, Day 1981, Ream and Mattson 1982). Changes in public attitudes by the 1960s and 1970s resulted in considerable environmental legislation and, in 1973, the subspecies (*Canis lupus irremotus*) was placed on the Endangered Species list. Doubts about the accuracy of previous subspecies designation resulted in listing the entire species as endangered in the contiguous United States. In Minnesota, wolves were reclassified to threatened in 1978. A Recovery Plan for the Northern Rockies was completed in 1980 and later revised and approved in 1987 (USFWS 1987). The plan recommended that wolves be recovered in northwestern Montana by encouraging natural dispersal from expanding Canadian populations.

Increased wolf reports in the late 1970s strongly suggested that there was a small population of wolves along the North Fork of the Flathead River in northwestern Montana, and a female was captured and radio collared in 1979, 11 km north of the international boundary (Ream and Mattson 1982, Boyd 1982). This wolf was located almost exclusively in British Columbia during the 15 months it had an active radio collar (Ream et al. 1985). Reproduction was documented approximately 10 km north of the border in 1982, and the first known den in the Western United States in 50 years was documented in Glacier National Park in 1986 (Ream et al. 1989).

Managing predator and prey populations is difficult given biological, sociological and economic constraints. The populations of wolves and ungulates we have been studying have the additional complication of straddling the international boundary between Montana and British Columbia. On one side of that boundary, wolves are considered an endangered species, while on the other, they are managed as a game species. Wolves here are contiguous with a large population extending through Canada and Alaska, though the population in Montana and southeastern British Columbia is a relatively recent and very narrow peninsular extension of this geographic range. Management goals, therefore, are different between the two countries. Ungulates, important to large predators, scavengers and humans, also move across the international boundary. In this paper, we describe the populations and movements of wolves in this area, sources of mortality in their ungulate prey and considerations in wolf management.

Study Area

This study was conducted in the North Fork of the Flathead River and Wigwam River Drainages in northwestern Montana and southeastern British Columbia (Figure 1), including lands within Glacier National Park and the Flathead and Kootenai National Forests in Montana and provincial lands in British Columbia. Wolves were also located occasionally on adjacent private lands that contained livestock, pets and permanent residents. Year-around human use of this area is low, with approximately 55 full-time residents in the study area (about 50 in the United States). Recreation is the primary human activity within Glacier National Park. Other lands are used to varying degrees from a diversity of human endeavors including timber harvest, petroleum exploration, fishing, hunting, trapping, guide-outfitting and various other forms of outdoor recreation.

Elevations in the study area ranged from approximately 1,020 m in the south to nearly 2,000 m at the headwaters of the Flathead, with most wolf use at the lower elevations. The dominant vegetation is lodgepole pine (*Pinus contorta*), interspersed with meadows and riparian areas. The Wigwam Drainage is steeper, narrower and contains relatively fewer open areas than the Flathead River Drainage.

The diversity of both predators and prey is high. Grizzly bears, black bears, mountain lions and coyotes are relatively common. Man is a predator on both car-

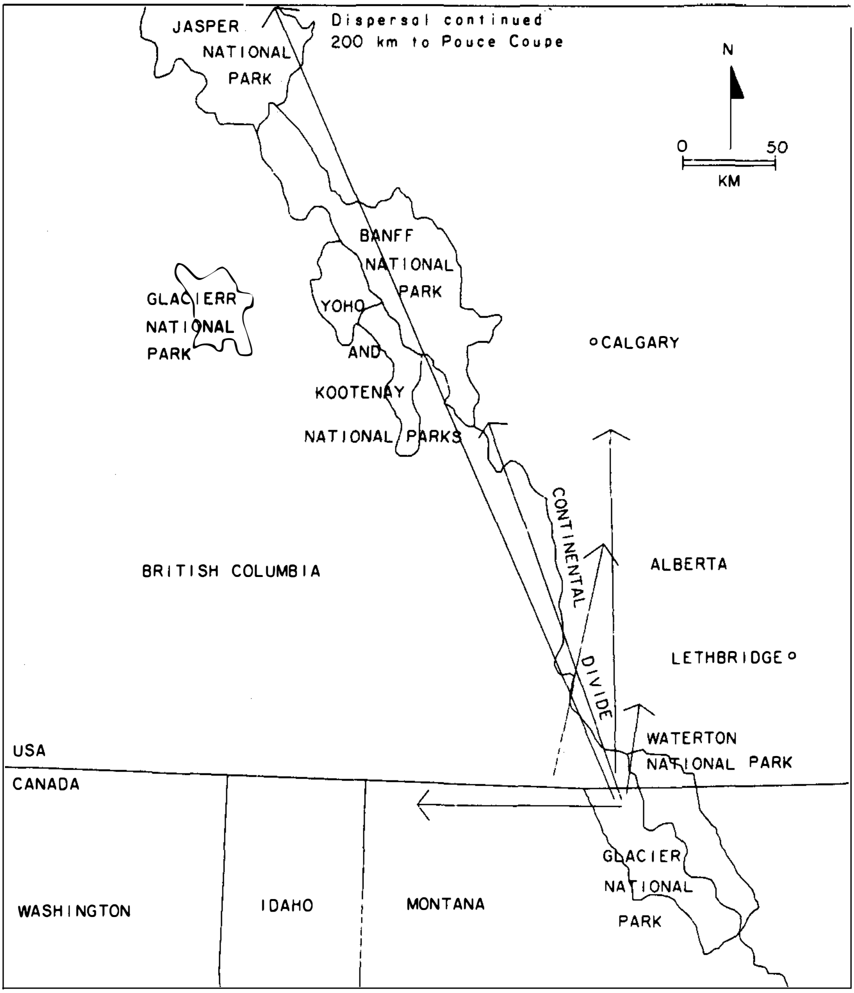

Figure 1. Home ranges of wolves in southeastern British Columbia and northwestern Montana, 1987–88.

nivores and herbivores throughout this area except within Glacier National Park. Prey for these large predators include white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), elk, moose (*Alces alces*), beaver (*Castor canadensis*), snowshoe hare (*Lepus americanus*) and, in the Wigwam Drainage, bighorn (*Ovis canadensis*).

Methods

Wolves were captured using leg-hold traps along roads and trails within the study area. Animals were immobilized and sedated using ketamine HC1 (11 mg/kg) and promazine HCl (2.2 mg/kg) injected with a jab stick. In addition to collecting standard measurements and a blood sample, each captured wolf over five months old was fitted with a radio collar (Telonics Inc., Mod 500).

Wolves were generally located from the ground twice per week and from the air three times per month. Pack sizes were recorded while obtaining locations of collared wolves. Attempts at keeping track of dispersing wolves were made, but they were usually found after they had either set up a new territory, or after they had been killed. Additionally, all reports of wolf mortalities in the study area were investigated.

White-tailed deer and elk were captured within or near Glacier National Park using modified, collapsible Clover (1956) traps during the 1989–90 and 1990–91 winters. Most were handled without chemical immobilization. Moose were immobilized from a helicopter during the same winters using a capture gun and a mixture of carfentanil (3.9 mg) and Rompun (0.25 mg). Females of all three species were fitted with motion-sensitive radio collars before release. Radio signals were monitored approximately daily to determine when mortalities occurred. When a mortality signal was heard, the carcass was carefully approached and necropsied to estimate cause of mortality (O'Gara 1978, Wobeser and Spraker 1980).

Results

Twenty-nine wolves were captured between 1979–90. Populations within the study area increased from at least 1 in 1979 to at least 34 in late 1990. There were probably seven wolves in this population in 1984 when the present intensive study began; the average rate of increase has been 30 percent per year between 1984–90 (Figure 2). The number of packs have ranged from one to four in that time, and all of these packs originated from members of the original 1984 pack (though there may have been immigrations of two females, and perhaps other wolves, from outside the study area). Fourteen wolf mortalities were documented. Additionally, at least 12 wolves disappeared from the study area (their fate is unknown), and a litter of pups died at less than two weeks of age. Of the 14 known adult mortalities, all (with the possible exception of one, which occurred during the 1990 big game hunting season in British Columbia) were human-caused. Three of the six long-range dispersers were killed, one of them illegally in Montana, and two legally harvested in Alberta. The only other illegal kill occurred during the 1985 hunting season in British Columbia. A total of eight wolves were legally killed during the 1987 and 1988 big game hunting seasons in British Columbia. The British Columbia Wildlife Branch closed the 1987 season on wolves after three were killed, but three more were killed, legally, during the 72-hour notification period following season closure. One wolf died a day after being accidentally caught in a researcher' bear leg-hold snare in 1982.

Most of the wolf packs throughout the study have had home ranges that straddled the international boundary. The first pack documented, the Magic Pack, had a 1985 summer home range primarily in British Columbia and the following winter was found primarily in Glacier Park. Home ranges of the Camas, Headwaters and Wigwam Packs in 1987–88 (Figure 1) were typical of the distribution of packs throughout the study, with two of the three straddling the border. In late January 1991, the packs were in flux. The large Camas Pack, which had two dens in 1990, has apparently split into two packs: the southern-most confining its movements to Glacier Park; the northern-most pack occasionally moving into British Columbia. A new

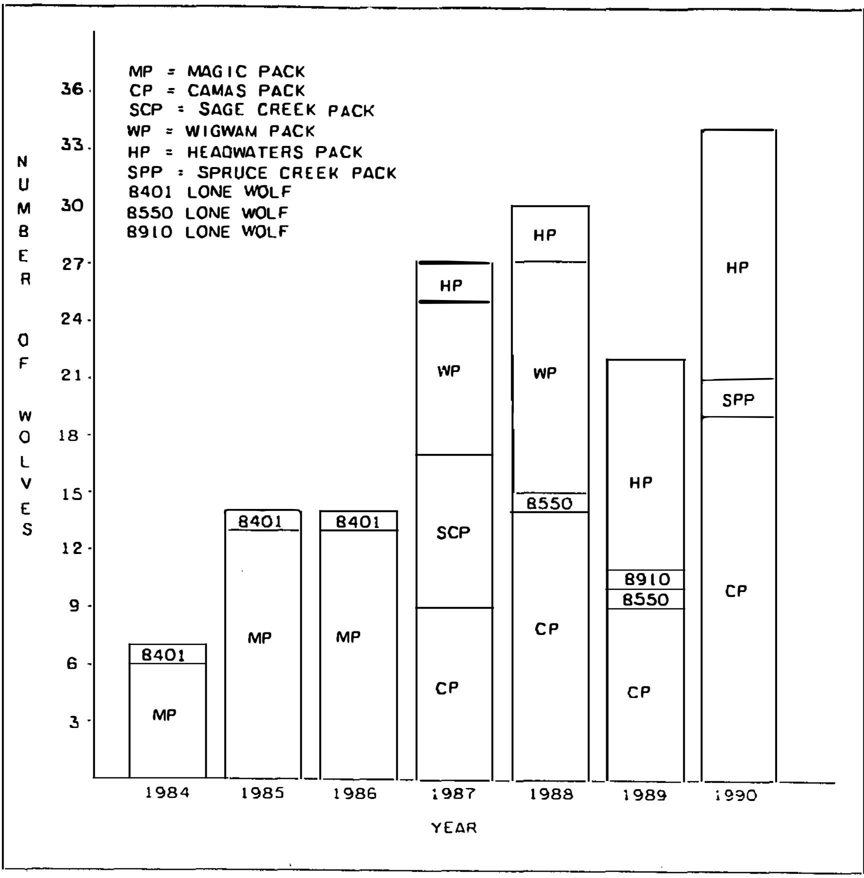

Figure 2. Wolf populations within the study area, 1984–90.

pack, consisting of a male from the former Wigwam Pack home range and a female from the Camas Pack, apparently established a home range straddling the border, and the Headwaters Pack confined its movements to the Wigwam River Drainage and the Headwaters of the Flathead River in British Columbia.

Six long-range dispersers have been documented from this population, and all but one have moved north in Canada. The lone female wolf that dispersed in the United States travelled straight west to the Yaak River Valley (approximately 130 km) in the northwestern corner of Montana, and remained there for 10 months before she was illegally killed. The other wolves dispersed north, in the probable direction from which this population originated (Figure 3). Dispersal distances have ranged from 50 to 840 km.

Thirty-seven moose (19 in British Columbia and 18 in Montana), 33 elk, and 36 white-tailed deer were radio collared during the 1989–90 and 1990–91 winters. All elk and white-tailed deer were captured in Montana within or very close to Glacier

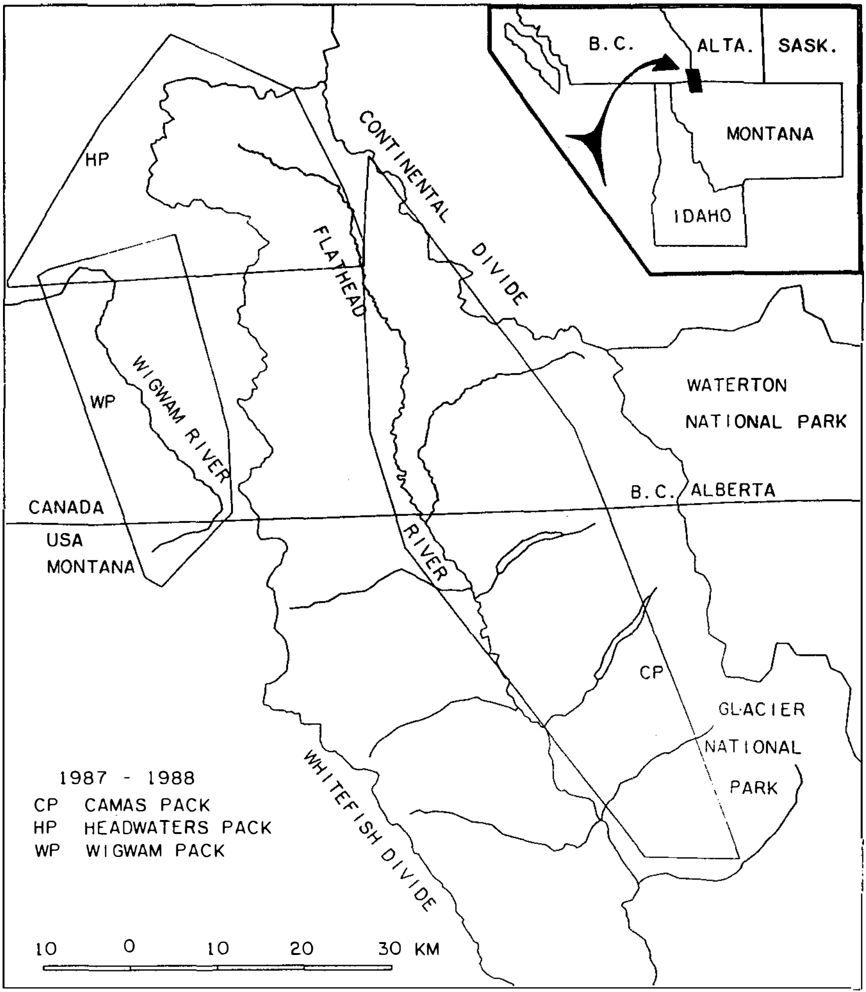

Figure 3. Distance and direction of dispersing wolves in southeastern British Columbia and northwestern Montana.

National Park. Fourteen ungulate mortalities (two moose, five elk, and seven deer) had occurred through February 15, 1991 (the first year of a multi-year study), with probable cause of mortality relatively evenly distributed among predators. Four of the mortalities were attributed to mountain lions (three elk, one deer), three to bears (two moose, one deer), three to humans (two deer, one elk), three to wolves (two deer, one elk), and one to coyotes (deer). It is premature to calculate mortality rates, but the data do reflect the diversity of predators utilizing these ungulates.

Many ungulates cross the international boundary between summer and winter ranges. Three of nine deer wintering at Kintla Lake spent the summer in British

Columbia, and 10 of 13 elk captured in Montana during winter had summer ranges in British Columbia. Seasonal movements are probably related to deep snow in the northern (British Columbia) portion of the Flathead Valley.

Discussion

Wolf populations increased from 1 in 1979 to at least 34 (four packs) within this study area in late 1990. While scattered pack activity has been documented elsewhere in Montana, the wolf population within and near Glacier National Park has been continuous since at least 1982. This wolf population probably originated from dispersers from the nearest wolf populations in Alberta or British Columbia, approximately 200 km away.

The finite rate of increase of this population (1.30) is very close to the average (1.29) of seven studies reviewed by Keith (1983). Wolves have a high biotic potential and wolf populations can increase despite moderate, human-caused mortality.

Wolves were eliminated from this area by the 1930s, when technology and access were much more limited than today, and it would not be particularly difficult for humans to achieve that goal again. Public attitudes and education, therefore, are extremely important. Attitudes of residents and hunters using the area south of the border were surveyed during the October-November big game hunting season (Tucker and Pletscher 1989). A majority of both groups supported wolves in this area (71.5 and 58.3 percent for residents and hunters, respectively), but support fell off rapidly if restrictions on human activities are necessary (e.g., support falls to 14.4 percent among hunters and 34.7 percent for residents if restrictions on hunting would be necessary to achieve wolf recovery). Additionally, 20.1 percent of the residents and 29.4 percent of the hunters were concerned with human safety if wolves recover. Other surveys have examined attitudes of visitors to Yellowstone National Park (McNaught 1987), where pro-wolf responses outnumbered anti-wolf responses by nearly nine to one. Attitudes of residents surrounding Yellowstone and residents of Wyoming in general were split between those supporting and opposing wolves (Bath and Buchanan 1989). Attitudes within southeastern British Columbia have not been quantified, but are probably not as supportive of total protection as those in the United States. Wolves in British Columbia are not rare, and the opportunity to legally harvest wolves is an important factor in the local tolerances toward wolves in the area (M. Jimenez personal communication).

Managers have been sensitive to attitudes and concerns of the public. The fact that wolves do not attack humans is stressed in public presentations, as is the relatively low numbers of wolves required to achieve recovery goals (10 breeding pairs for three successive years). Information on the numbers of wolves currently in the area, relative sources of ungulate mortality, and that few (if any) changes in the current uses of public lands will be necessary to recover wolves in Montana, are also stressed.

Of the four wolf packs currently in the study area, only one spends all of its time within the United States, and one of the packs spends all of its time within British Columbia. For this population to continue to expand into the United States, cooperative management between the United States and British Columbia must occur.

Ungulate populations in this area also show no respect for international boundaries. Because of these movements and the continued dependence of the United States on colonizing wolves from British Columbia and Alberta, cooperation between the two countries in wolf management is essential. Coordination between British Columbia and United States management agencies ensured that recovery of wolves in the south would not be precluded by management practices in the north. Similarly, United States wolf management must be sensitive to Canadian objectives.

While it is very early in the ungulate morality studies, preliminary data suggest that wolves are only one of at least six predators that kill ungulates here, and management for desired prey numbers could involve many different strategies.

Wolf Management in British Columbia

British Columbia was one of the first areas in North America to protect and encourage wolf recovery. British Columbia was the first wildlife agency in North America to do away with the bounty on wolves (1955) and, in 1966, protected wolves from indiscriminate killing by classifying them as a big game animal. Seasons were closed in the southeastern corner of the province (the area adjacent to Glacier National Park) in 1967 to encourage wolf recovery. Wolf hunting and trapping remained closed until population goals were met in 1987. A limited quota season in 1987 resulted in the harvest of six wolves, and the following year two were killed. The season was closed in 1989 and 1990, because wolves were below population goals for the area (due, in part, to the loss of an entire litter in the United States, probably from disease, and the sudden disappearance of another pack in British Columbia in 1989) and to assist the wolf recovery effort in the United States. Sharing of information is critical in the joint management of this international population.

The British Columbia Wildlife Branch will continue to use regulated hunting and trapping to control wolf population growth to meet provincial wolf population objectives and to balance wolf predation on ungulates with the demands of hunters. Provincial biologists believe that most local residents will tolerate wolf recovery if wolves do not reach levels where hunter opportunity to harvest ungulates decreases substantially. If wolves are allowed to reach levels where hunter harvest of ungulates is seriously impacted, support for wolf recovery will quickly fade and illegal, uncontrolled taking will result.

Wolves that kill domestic animals will not be tolerated by local residents. Wolves that attack livestock in British Columbia are removed by Animal Damage Control Specialists. British Columbia does not provide compensation to producers who lose livestock to wolves. The area in British Columbia just north of the international border does not contain many livestock and no wolves have been removed because of depredations in recent times.

Wolf Management in Montana

Wolves became protected by both the federal government and state of Montana Endangered Species Acts in 1973. All hunting and trapping of wolves is prohibited until wolves are removed from protection of the Act. After that time, management will revert to the State of Montana and, on Indian Lands, to Tribal Governments.

Both Montana and British Columbia consider large predators an important part of their wildlife trust to be managed and conserved along with other resources. Wolf recovery in Montana is being managed in much the same manner as recovery in British Columbia was accomplished. Wolves are protected from human harvest until population levels reach recovery levels. Problem animals, those that exhibit behavior that leads to local intolerance of wolves (such as killing domestic animals) are removed by professional resource managers through programs that target specific individuals. The Federal Wolf Recovery Plan (USFWS 1987) recognized that increased numbers of wolves would result in occasional losses of livestock, but losses would be minimal if the individual problem wolves were quickly controlled. Currently, any wolf that kills livestock is captured and translocated. Wolves that repeatedly kill livestock are either killed or placed in captivity. None of the livestock within the North Fork study area have been attacked by wolves, however, wolves have killed livestock elsewhere in Montana and were controlled in 1987, 1989 and 1990.

While there is no government program that compensates livestock producers for losses to wolves in the western United States, the Defenders of Wildlife currently funds a compensation program that pays producers 100 percent of the value of confirmed losses and 50 percent of the value of possible wolf-caused losses. A producer who lost calves in spring 1990, received full fall market value through that compensation program.

Ungulate Management

Objectives for ungulate management are fairly similar on either side of the international border, with the exception of Glacier National Park. Objectives which are desirable for ungulates in a Park sometimes conflict with state and provincial objectives on the same populations (high hunter opportunity and success, populations below habitat carrying capacity to reduce conflicts with private landowners and forest regeneration). Close working relationships between the government agencies involved will ensure that ungulates continue to provide multiple benefits.

Hunting is an important social and economic activity (USFWS 1988, Duffield 1988, Brooks 1988) within our study area, and the perceived impact of wolves on ungulate populations is one of the most common reasons people oppose wolf recovery both in Montana and British Columbia (Tucker and Pletscher 1989, M. Jimenez personal communication). However, viewing wildlife and existence values, particularly for large carnivores, are important and contribute an increasing benefit to local economies. The misconception that wolves alone will regulate ungulate populations is widespread. While our findings in the North Fork are preliminary, it is obvious that many predators kill and consume ungulates. Mortality caused by predators is only one of many factors that affect ungulate density, and all factors must be addressed in a comprehensive ungulate management plan that meets both consumptive and non-consumptive public demand for diverse wildlife resources.

Summary

Wolf management has successfully led to the recovery of wolves in many areas of British Columbia, including the Flathead Valley. The same strategy used to restore wolves in British Columbia was employed throughout the United States to restore the multitude of wildlife populations that were devastated around the turn of the century, and a similar strategy is currently being used to increase populations of wolves in Montana. The combined and cooperative efforts of the British Columbia Wildlife Branch, United States Fish and Wildlife Service, National Park Service, USDA Forest Service, Montana Department of Fish, Wildlife, and Parks, and the general public in Montana and British Columbia will be required to continue the progress that has been made to date with these cross-boundary populations. While the agencies can set the legal framework and gather biological data, public acceptance is the factor that will determine success.

The wide variety of ungulate mortality factors in the study area gives wildlife and land managers a wide variety of management options if problems occur after wolf recovery. These options include keeping wolf numbers low to reduce predation rates, reduction of other predators or habitat improvement to increase ungulate recruitment.

A major reason for the success of wolf recovery thus far in Montana has been the wildlife management policies of the British Columbia Wildlife Branch and close working relationship with the United States wolf recovery program. Continuation of this relationship will benefit both ungulates and wolves on both sides of the border.

Acknowledgments

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Deer and Coyotes: The Welder Experiments

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The white-tailed deer (*Odocoileus virginianus texanus*) herd on the Welder Wildlife Foundation Refuge (WWFR) has been intensively studied and monitored since 1954. Studies of the interactions of coyotes (*Canis latrans*) and deer, and impacts of weather, mainly drought, on the deer herd also have been conducted. Graduate students from several universities conducted most of the field research to satisfy thesis and dissertation requirements. The staff of the Foundation also has conducted various investigations and monitored parameters of the herd over the years. Data from these research and monitoring programs have been published in several periodical and journals.

Although most of the studies were designed independent of other studies, there were some planned sequential linkages during the 35 years. When data from these studies were combined and monitoring data were included, an interesting account of the relationship of coyote predation on the herd emerged. This paper is a review of these relationships.

A review of predator/prey interactions in large mammal populations is given by Connolly (1978). He examined predator/prey research and reported that very few studies implicated predation as the sole controlling influence on large herbivore populations. However, he concluded that predators acting in concert with weather, disease and habitat changes do have important effects on prey numbers.

With his review, and conventional wisdom and dogma in mind, we sought to determine if coyotes controlled numbers in the Welder herd that has not been commercially or sport hunted for more than 35 years.

The Welder Wildlife Foundation Refuge

The 3,158-hectare WWFR is located in San Patricio County in the Coastal Bend Region of south Texas. It consists primarily of grassland communities with elements of tallgrass and shortgrass prairies of the mid-continent (Drawe et al. 1978). Most of the 16 plant communities have been invaded and are dominated by several species of woody shrubs and trees. Mesquite (*Prosopis glandulosa*) several species of *Acacia*, Mexican persimmon (*Diospyros texana*), lime pricklyash (*Zanthoxylum fagara*), brazil (*Condalia obovata*) and lotebush (*Ziziphus obtusifolia*) are principal woody species. Live oak (*Quercus virginiana*) occurs on about one-fourth of the refuge. The average growing season is over 300 days with the first frost usually occurring in early to mid-December. Precipitation averages about 81.3 cm ± 28.6 cm and falls as rain in two major periods, April-June and October-December. The smallest amount of rainfall measured was 39.4 cm in 1989 and the most rainfall was 151.1 cm in 1983.

The WWFR is operated as a working cattle ranch with cows and calves. Cattle, almost exclusively Hereford/Brahman crosses, have been stocked at an average rate of one cow per 5.7 ha since 1974. Every cow and every pasture are included in controlled grazing experiments featuring wildlife/livestock interactions under several grazing treatments and stocking rates (Drawe and Cox 1979, Drawe 1988, Drawe in press). Cattle have been used with some success to manage successional stages of the vegetation to create or maintain desired wildlife habitat (Teer 1987, Guthery et al. 1990).

The Deer Herd

The deer herd is non-migratory and unhunted. Field-dressed weights of mature bucks and does average 50.5 kg and 40 kg, respectively. Estimates of natality and sex ratios in adult deer have fluctuated from year to year within limits that one might expect in an unhunted herd. These estimates are obtained from both aerial censuses and from ground or road counts. Fawn survival has improved since the screwworm fly (*Callitroga hominivoraz*) was eradicated; however, it appears that other mortality factors compensate for losses once caused by screwworm infestations.

Knowlton (1976) reported that fawn survival to weaning was related to precipitation during gestation, and that fawning advanced by 10 or more days when rainfall was abundant. The relationships between fawn survival and rainfall, and timing of conception (and thus of parturition dates) and rainfall, were reaffirmed by Kie and White (1985). They found no relationship between conception rates and deer numbers at densities between 26–60 deer per km^2. Conception rates were lower for both yearling and mature does when deer densities peaked at 84 deer per km^2.

The first census of the herd was made in 1962 some eight years after the WWFR was established. Early censuses were made by marking deer and using the Lincoln Index method to arrive at densities on at least a part of the refuge (Knowlton 1964). Fixed-wing aircraft were employed in 1965 and 1966 by White (1966) and in 1967 by staff. Evans (1975) counted deer from a helicopter in 1970 and 1971, and Kie

(1977) made roadside counts in 1972, 1973 and 1974. In all of these efforts, samples were obtained on transects and expanded to the entire area of the refuge.

At least one aerial census has been conducted annually by helicopter since 1975. The refuge is gridded with permanent markers on each 16.2 ha block, and flight lines were established on these lines and used each year. Complete censuses (100 percent coverage) were conducted from 1970 to 1978. We examined these data to determine if census results varied with intensities of sampling and found that a 50 percent coverage was adequate and very little different from 100 percent coverage (Teer et al. 1985). Thus, the censuses were conducted along every other flight line after 1978. The width of the transects was 100 m on each side.

The herd has fluctuated within rather confined limits with a tendency toward stability at about 34.2 $\pm$ 10 deer per km^2 from 1962 through 1990. Although all census techniques yielded reasonable estimates, they fluctuated much less when helicopters were used from 1975 through 1990. Censuses have tracked other population parameters of the herd in response to rainfall patterns since 1975. However, while we have been able to estimate the precision of estimates, we know very little about their accuracy. We have used numbers of deer seen on the transects in developing density estimates; i.e., without any correction factors to account for differences in visibility of deer in varying habitat types or distances they were seen from the aircraft (Teer et al. 1985, De Young et al. 1989).

The Coyote Population

Coyotes are common residents of brushlands in southern Texas. Control of their numbers is not practiced on the refuge. They are commonly seen in daylight hours and heard on any night. Using indices of abundance obtained from visits of coyotes to coyote-getters on standard lines, Knowlton (1972) concluded that southern Texas had a greater density of coyotes per area than any of the other major ecological regions in Texas. Populations ranged from 0.2 to 0.4 per km^2 and reached 2.3 per km^2 in extremely favorable habitat. He did not report densities of coyotes in his studies on the WWFR (Knowlton 1964).

Five coyotes (1.28 coyotes per km^2) were removed from the 391-ha Coyote Pasture on the WWFR in June and August 1973. Kie (1977) considered all coyotes to have been removed in that year although a total of 10 were later removed in an 18-month period beginning in June 1974 and ending in January 1976. Presumably, these animals went over the "coyote-proof" fence and were removed immediately upon discovery.

Andelt (1982) has the most credible data on coyote density on the refuge. In his studies of behavioral ecology of coyotes on the WWFR, he trapped coyotes and fitted them with radio transmitters and reported the following: "Coyote density was estimated on an area of 14.0 km^2 on the western portion of the WWFR during April and October 1978 and on an area of 22.4 km^2 during April and October 1979. Prewhelping density was estimated at 0.9 and 0.8 coyotes per km^2 during April 1978 and 1979, respectively. Fall densities of 0.9 and 1.0 coyotes per km^2 (including juveniles) were estimated during October 1978 and 1979, respectively."

Andelt's estimates conform closely with estimates of about one coyote per km^2 reported by Kie. Undoubtedly, numbers of coyotes fluctuated from year to year as conditions varied—primarily abundance of prey and vegetable foods.

Food Habits of Coyotes

It is generally accepted that coyotes are adaptable and opportunistic in their feeding habits. They take foodstuffs that are abundant and easily caught or gathered. An abundance of rodents, lagomorphs and plant foods may be important in buffering the take of species desired by man.

Andelt et al. (1987) summarized food habits of coyotes from 6,354 scats collected in 1961–62 by F. Knowlton, 1973–1974 and 1975–76 by J. Kie, and 1978–79 by W. Andelt. Mammals averaged 64 percent of the diet in all seasons combined. Fruits, insects and birds constituted most of the remainder.

The most dramatic change in coyote diets was their change to deer in early June, a change which coincided with the fawning season (Figure 1). Seventy-five percent and 85 percent of the diets of coyotes consisted of deer in June 1961 and 1962, respectively, of Kie's and Andelt's collections in the 1970s and 1980s. As fruits became more abundant in summer and as fawns became more mobile with age, coyote diets switched to fruits and other materials.

Without question, fawns comprised the chief age class in coyote diets in the fawning season. Deer again became rather prominent food items during late winter and early spring. Adult and young animals were involved in this latter season, but some deer

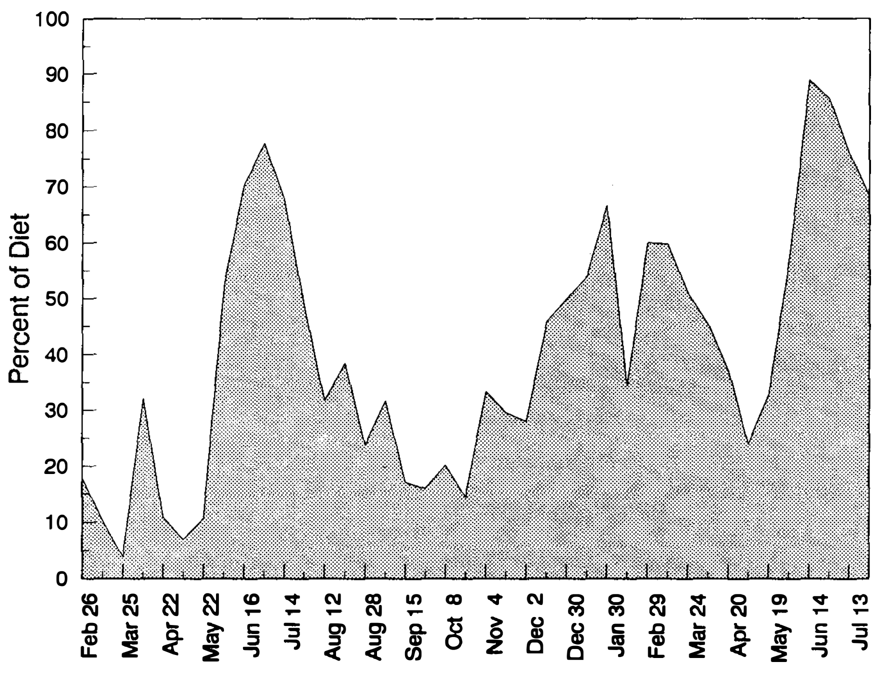

Figure 1. Consumption of deer by coyotes on the Welder Wildlife Refuge (after Knowlton 1964).

were probably taken as carrion. Evaluation of diets from the four collections showed conclusively that diets varied seasonally with changes in prey abundance and vegetation (Andelt et al. 1987).

Studies of Fawn Mortality

Studies by Knowlton (1964) and Andelt (1982) established that deer, primarily fawns, were important items in the diets of coyotes on the refuge. Their work verified the fact of predation if not its effects on herd numbers. Their work did not establish whether the fawns were taken as prey or as carrion.

Fawn mortality was very high before screwworms were eradicated in the late 1950s. Knowlton (1964) indicated that 30 percent of fawns caught and marked in 1961 had screwworms. Only 8 percent of fawns marked in 1962 had screwworms. Many fawns were infested with screwworm larvae in their navels. Does often were infested in their vulvas after birth wounds. Bucks also were subject to screwworm infestations, primarily on their ears, velvet antlers and backs where ticks had caused an issue of blood or where the bucks had scratched the centers of their backs with their antlers to remove ticks.

Coyotes undoubtedly fed on carrion to a great extent during this period. After the screwworm was controlled, other mortality factors surely became more important. Loss of fawns to poor nutrition has always been important in all deer ranges of the state primarily because of conservative harvest rates.

To verify that coyotes were taking fawns as live prey, Cook and his colleagues captured 81 fawns from one to 12 days of age in 1965 and 1966 (Cook et al. 1971). Each was fitted with a radio transmitter and relocated several times each week until about 60 days of age.

Seventy-two percent of the fawns died during this period. Of these deaths, 93 percent were lost during the first month of life. Predation was known to account for 60 percent of the losses. Another 22 percent were lost to uncertain causes of which some were almost certainly attributable to coyotes (Figure 2). The remaining 18 percent were lost as a result of starvation, disease or accident.

Fawn-at-heel counts on the WWFR showed that survival of fawns to weaning (about 4.5 months of age) was about one-third of those alive at parturition (Kie and White 1985). However, even with the data from scat analyses and from the radio-tagged mortality studies, sufficient evidence was not available to conclude that losses of deer to coyotes influenced deer herd numbers.

Studies of a Coyote-free Pasture

The 391-ha Coyote Pasture on the WWFR was fenced to exclude coyotes in 1972 to observe deer responses to the absence of predation. The fence was made of tightly-meshed net wire, dug down into the soil about 25–30 cm, and aproned out 25–30 cm so that coyotes could not go through or dig under. A battery-powered electric wire was placed on top of the fence and secured to each post with a ceramic insulator. The fence was standard stock-fence height, about 142 cm, which deer could jump with relative ease but which was relatively coyote-proof.

Coyotes were removed from the pasture by traps, snares, coyote getters, and by shooting from the ground and from a helicopter. Five were removed at the outset,

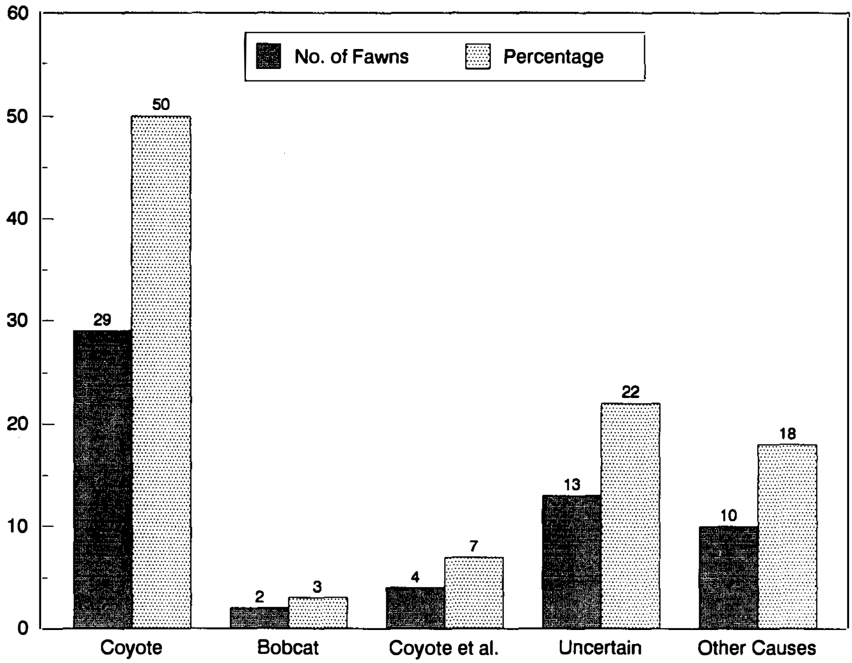

Figure 2. Causes of mortality of 58 of the 81 radio-collared fawns that died during 1965 and 1966. (Cook et al. 1971). Although coyote predation was probable in several cases they were placed in an uncertain category. Other causes relate to starvation, disease and accident.

and another 10 were removed over the next 18 or so months, whenever sign or sight revealed their presence. Coyotes that entered likely crossed the fence by climbing over it. Bobcats were present in small numbers. No attempts were made to remove them because they are extremely agile and very adept to climbing fences. Several were seen doing this during Kie's study.

Cattle were stocked in the Coyote Pasture at the same rate as outside. Density and composition of the herd was intensively monitored by students and staff for the next eight years. Monitoring of the herd continued even after 1980; however, after 1982, the ''coyote-proof'' fence began to rust and coyotes passed freely in and out of the pasture through holes near ground level.

The immediate response to removal of coyotes was an increase in the deer herd (Figure 3). Fawn survival was about 30 percent higher inside the pasture compared to survival outside the pasture where coyote numbers had not been controlled (Figure 4). The deer herd responded to this treatment until they began to reduce the food supply in the pasture. When forage became limiting, deer numbers declined, and surveys and necropsies of dead deer in the Coyote Pasture suggested mortality was caused primarily by low food supply. While few data are available to show trends in the vegetation, forbs, a staple food item in deer diets in the Coastal Bend Region of Texas (Drawe 1968, Chamrad and Box 1968), decreased in the Coyote Pasture during the study period.

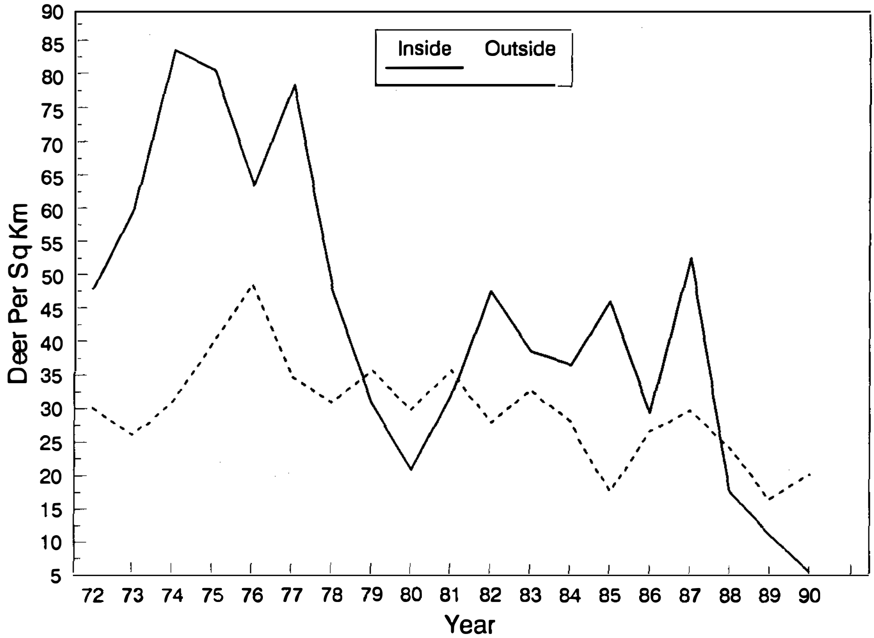

Figure 3. Deer population estimates inside and outside the coyote-proof pasture.

Apparently, deer within the 391-ha exclosure were forced to feed upon less desirable and less nutritious foods as the herd increased (Kie et al. 1980). Forbs comprised 76 percent of deer rumen contents inside the exclosure but 87 percent outside. Grasses made up 21 percent inside and 10 percent outside. The exclosure herd had lower rumen levels of crude protein, higher levels of calcium and higher calcium/phosphorus ratios than the deer outside.

Increases in density of deer inside the Coyote Pasture were accompanied by increased parasite loads. Yearling and fawn deer inside had higher average numbers of total abomasal nematodes, *Haemonchus contortus*, *Ostertagia* spp., and *Trichostrongylus* spp. (Pedersen 1980). In addition, bled carcass weights of yearlings and fawns from inside the Coyote Pasture were less than those collected outside. Yearling weights inside were 28.8 ± 5.0 kg and 33.8 ± 5.1 kg outside. Fawn weights inside were 16.6 ± 2.4 kg and 20.9 ± 2.4 kg outside.

After the initial decrease in herd numbers in the Coyote Pasture, numbers began to build again much as one would expect when food supplies returned to normal. Coyotes were present during these times and predation probably prevented populations from reaching the high numbers which occurred during the years of predator control.

Drought and Deer Numbers

The most dramatic changes in deer numbers on the WWFR have occurred in years of drought. Rainfall patterns from 1963 through 1990 show a trend of above-average

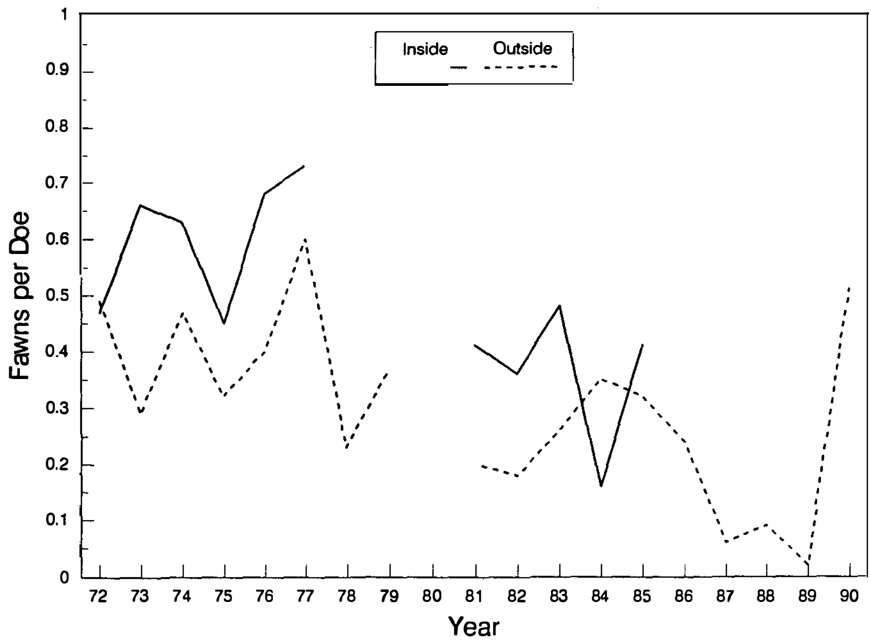

Figure 4. The number of fawns per doe inside the coyote-proof pasture and the number estimated on the remainder of the refuge from fall roadside counts.

amounts until about 1981, followed by a trend of below-average amounts every other year from 1982 through 1988. Rainfall from 1988 through 1990 has been significantly below normal (Figure 5).

Vegetation on the refuge changed significantly from a shortgrass community with few forbs in 1957–1958, to mid-grasses and abundant forbs by 1973 (Figure 6). After 1973, with changes in the cattle operation from a steer to a more conservative cow/calf operation and with increased rainfall during a 10-year wet cycle, range vegetation trended toward more grasses, few forbs, and loss of cacti and other forage species of importance in the diets of deer.

Deer numbers declined from 1987 through 1990 to the lowest number since counts began. Fawn survival in 1987, 1988 and 1989 was extremely low, 6, 9 and 2 percent, respectively. The fawn crop in 1990 (51 percent) was higher than normal following early spring rains which provided dense forb cover during the fawning season. Although we cannot be certain, it appeared that increased ground cover was responsible for lowered fawn predation.

Conclusions

While we have attempted in this evaluation to determine the role that predation by coyotes plays in the population dynamics of white-tailed deer, we offer a conclusion short of alleging that coyotes have controlled the deer herd since 1954. We

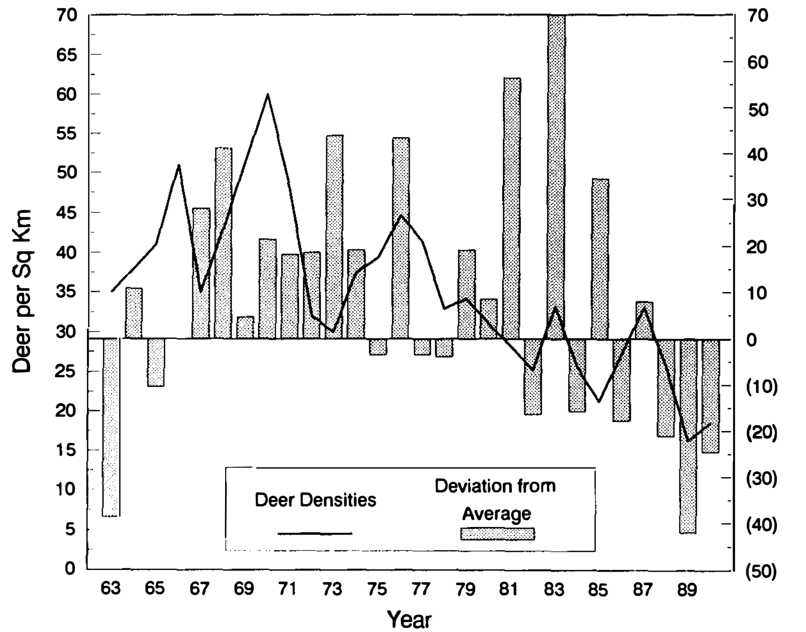

Figure 5. Deer population estimates from 1963 to 1990 compared to the amount of annual rainfall above or below average.

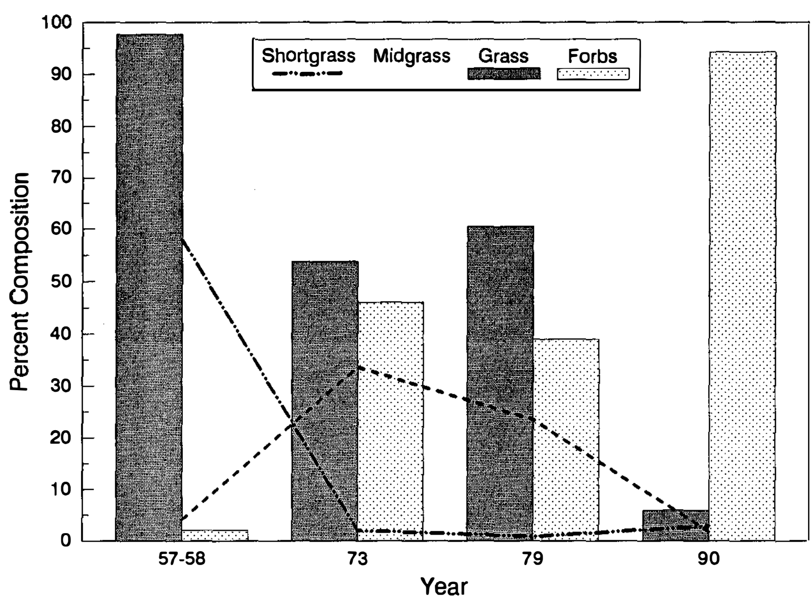

Figure 6. Percentage composition of three species of shortgrass and midgrass and total percent composition of grasses and forbs (Drawe unpublished data).

can say unequivocally that coyotes take a large portion of the fawns each year during the first few weeks of life. We can also conclude that higher losses of fawns occur during drought. These greater losses during droughts result in part from reduced vegetation growth. Less cover increases predation and less forage increases nutritional stress.

Predation and other environmental perturbations acting together are important factors in herd stability. It seems obvious to us that coyotes can be used in management of deer numbers. Control of coyotes need not be a management strategy when numbers are not cropped by hunting or natural means. Conversely, control of coyotes can be a management strategy where there is adequate habitat and deer numbers need to be increased for greater productivity.

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Forty Years of Wolf Management in the Nelchina Basin, Southcentral Alaska: A Critical Review

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Wolf (*Canis lupus*) management in North America ranges from complete protection of threatened or endangered populations to efficient control programs designed to suppress wolves that compete with humans for wild ungulates or domestic livestock. Most remaining North American wolf populations are between these extremes, classified as game animals or furbearers, and subject to liberal seasons and bag limits. However, such wolves often are managed primarily as predators rather than game animals or furbearers, and wolf management is often directed at keeping populations low to minimize predation on ungulates. Managers are faced with the difficult problem of balancing long-term conservation and protection of wolf populations with providing sustained yields of wolves for hunters and trappers and reducing competition for ungulates. This balance is difficult to achieve; wolf populations in certain areas of Alaska and Canada have been kept at low densities for long periods because priorities to reduce predation were dominant (Carbyn 1987, Peterson et al. 1984, Ballard et al., 1987). This paper reviews a management case history where wolves in Alaska have been kept at low densities for 40 years by control programs, hunting and trapping, and discusses the need to strike a better balance between wolf numbers, ungulate densities and wolf harvests in an area where high ungulate harvests are a management priority.

Wolf Numbers and Management Programs, 1950–1989

The Nelchina Basin in south-central Alaska is a large, remote area of about 24,000 square miles (62,000 km^2) including portions of four different mountain ranges that ring its periphery. Only about two-thirds of the land area lies below 3,750 feet (1,250 m) elevation, the upper limit of suitable habitat for moose (*Alces alces*), caribou, (*Rangifer tarandus*), and wolves. Rausch (1969) identified this area as the most important wildlife recreation area in Alaska. Twenty years later, the area still provided about 16 percent of the statewide moose harvest and 7 percent of the caribou harvest for subsistence and sport hunters, including those in Anchorage and Fairbanks, Alaska's largest population centers.

No estimates of wolf numbers in the Nelchina Basin exist prior to 1960 but early explorers reported that wolves and their prey were scarce during the late 1800s (Glenn and Abercrombie 1899 cited in Skoog 1968:280). Wolves were shot, trapped and poisoned throughout south-central Alaska during the first part of the 20th century as trappers and miners settled the land. This, coupled with the relative scarcity of ungulates and diseases introduced by sled dogs, probably kept wolf numbers low over much of Alaska until the 1930s (Murie 1944). During World War II, wolf numbers apparently increased as trapping pressure declined as did hunting of moose and caribou.

In 1948, the U.S. Fish and Wildlife Service launched a wolf control program in the Nelchina Basin. Burkholder (1959) reported over 200 wolves were taken by poison and aerial shooting during 1948–1951 in a portion of the area where 12 wolves were estimated to survive in 1953 (Atwell 1964). Wolf control ended by 1955 and, in 1957 the area was closed to the taking of wolves and remained closed until 1968.

Aerial surveys in February 1962 (Atwell 1964) and November 1965 (Rausch 1967) indicated that wolves had increased to at least 200 animals by the mid-1960s when moose and caribou numbers peaked synchronously after erupting in the 1950s (Van Ballenberghe 1981, 1985). Problems in interpreting the wolf survey data preclude precise estimates of wolf abundance in the 1960s (Van Ballenberghe 1981) but it is apparent that persistent illegal aerial hunting reduced the population's rate of increase (Rausch 1967, 1969).

In 1968, aerial hunting was reinstated and 120 wolves were taken (Rausch 1969). Public aerial hunting continued until it was banned in 1972 (Rausch and Hinman 1977). During 1972–1989, aerial hunting was replaced by a method of airplane pursuit and harvesting variously termed aerial trapping, land-and-shoot hunting, or same-day-airborne hunting, whereby hunters in airplanes could not shoot directly from the air. Instead, they were required to land before shooting, and in practice spotted and pursued wolves until they entered suitable terrain or frozen rivers and lakes where landing, shooting and retrieval were possible. Legal land-and-shoot (LAS) hunting has been accompanied by illegal aerial hunting in recent years (Ballard et al. 1987).

Accurate data on wolf harvests in the Nelchina Basin have been available since 1972 when a mandatory pelt-sealing program was implemented. During 1977–1988 a mean of 91 wolves was harvested annually. The total harvest includes 60 animals removed in an experimental control program during 1976–1978 in a 2,800 square mile (7,250 km^2) area in the northern part of the Basin. Harvests ranged from 48 to 132 wolves per year and exceeded 100 animals during 8 of 17 years (1972–1988). The proportion of the harvest taken by LAS hunters is unknown but probably exceeded 75 percent during years when deep snow favored this practice.

During 1975–1982 research on wolves in the Nelchina Basin included radio-telemetry studies that allowed accurate population estimates. Ballard et al. (1987) reported that wolf densities declined during this period from 10.3 per 386 square miles (1,000 km^2) in autumn 1975 to 2.6 per 386 square miles (1,000 km^2) in spring 1982. For the entire Basin, these densities indicated a total population of 426 and 109 wolves, respectively. The autumn 1975 population likely represented the maximum number of wolves present after recovery from the control program in the early 1950s. Spring numbers during 1977–1982 (174–109) were the lowest since the early 1960s. Ballard et al. (1987) reported that during 1975–1982 human harvest was the primary controlling factor for wolves; legal (46 percent) and illegal (34 percent) human harvest constituted 80 percent of total mortality.

Population estimates after 1982 were generally based on late-winter track surveys in a portion of the area. Autumn estimates fluctuated between 250 and 300 wolves; spring estimates were 130–200. Posthunting estimates in spring prior to denning during 1977–89 averaged 146 wolves per year.

In 1973, the Alaska Department of Fish and Game (ADFG) published a set of wildlife management policies that were reviewed and endorsed by the Alaska Board of Game in 1980. These provided broad guidelines for the management of wolves and their habitat and recognized that sustained yield management of wolves was a priority use for this species. In 1982, the Board of Game provided a supplement to the 1980 policies dealing specifically with wolf control. Conditions for reducing wolf populations competing with humans for ungulates were identified, but conventional hunting and trapping and its effects on wolf numbers were specifically excluded from the definition of wolf control.

In the Nelchina Basin, a management plan for wolves with a minimum population objective of 150 wolves in the posthunt population has been in effect since 1976. Hunting seasons have been from August through April; trapping seasons were from November through March. No bag limits for either season were in effect prior to 1990.

Ungulate Population Trends and Harvests

Following the moose and caribou eruptions of the 1950s that peaked in the mid-1960s, populations of both species in the Nelchina Basin declined to low points during the period 1972–1975. Caribou declined from about 80,000 in 1964 to about 8,000 in autumn 1972 (Van Ballenberghe 1985). Moose apparently peaked in 1960 at about 25,000 (Bishop and Rausch 1974) and declined to perhaps 12,500 by 1975 (Van Ballenberghe 1985). Populations of both species subsequently increased during 1975–1989 with caribou and moose reaching about 40,000 and 25,000 animals, respectively, by the end of this period.

Ballard et al. (1991) reported that the finite rate of increase of moose in a portion of the Basin was 1.03–1.06 during 1980–1983. During 1972–1985, caribou increased at a finite rate of 1.10 (Van Ballenberghe 1989). Both species were hunted during this period and subject to predation by wolves and brown bears (*Ursus arctos*). During 1984–1988, moose harvests averaged 1,004 annually; females constituted only about 2 percent of the harvest. Either sex caribou harvests averaged 1,284 per year during the same period. Harvests of moose and caribou increased steadily during the 1980s as their populations increased in concert with demand by sport and subsistence hunters. Clearly, the ungulate-predator complex in the Nelchina Basin has been managed primarily to provide hunters with large yields of moose and caribou; wolves and brown bears (Van Ballenberghe 1981, Ballard and Larsen 1987) have been reduced in order to achieve this management goal.

Discussion

Exploitation by humans has been the primary controlling factor of wolves in the Nelchina Basin from 1950 to 1989. Early efforts to poison and shoot wolves nearly extirpated them from this area. Subsequent recovery of the population was slowed by illegal aerial hunting; legalization of this practice between 1968 and 1972 further reduced wolf numbers. After a population peak exceeding 400 wolves in autumn 1975, LAS hunting consistently kept numbers low, and the management plan objective of a minimum posthunt population of 150 wolves was achieved between 1977 and 1989. By the end of this period, moose and caribou populations had increased to levels reminiscent of the eruption peaks that followed the wolf poisoning programs of the 1950s.

The suppressing effects of hunting and trapping on wolf numbers is illustrated by Fuller's (1989) analysis of prey biomass dynamics in relation to wolf population density. Fuller (1989) reported that wolf numbers were directly related to ungulate biomass with potential wolf density in the absence of human-caused mortality ultimately limited only by ungulate availability. Fuller's (1989:21) equation relating these variables indicates that wolf density in the Nelchina Basin might have been about three times higher during 1975–1982 without human exploitation with about 776 wolves present during winter. During the 40 years between 1950 and 1989, wolf numbers never exceeded about half this even when prey biomass peaked in the mid-1960s.

With management objectives for the Nelchina Basin's predators and ungulates favoring high ungulate yields for hunters, it is not surprising that wolf numbers were kept below the upper limits set by prey availability. But precise relationships between wolf density and prey yields for humans are poorly documented, especially in environments containing brown bears as well as wolves, and more than one species of ungulate prey. Balancing wolf density and ungulate yields for hunters may then result in managers choosing the conservative option of keeping wolf densities well below the point where moose and caribou yields are reduced for humans. If ungulates increase significantly as a result, wolf densities may then be kept much lower than necessary to maintain high ungulate harvests. This appears to be the case for the Nelchina Basin where, by 1983–1984, there were about 200–300 moose per wolf (Ballard et al. 1987) and caribou were abundant. Under these conditions, it is likely that posthunt wolf numbers in 1984 could have been twice as high as actually occurred (238 vs. 119) without reducing yields of moose or caribou or jeopardizing continued population growth of these two species.

The Nelchina Basin is only one of several areas in Alaska where predator management to increase ungulate yields for humans has occurred (Gasaway et al. 1983). These programs were implemented when research indicated that wolves and/or bears exerted controlling effects on moose that could be lessened through predator reductions. Skoog (1983) summarized the rationale for wolf control programs in Alaska that used aerial shooting from helicopters to ultimately remove 1,300 wolves between 1976 and 1983. Skoog (1983) emphasized that wolf control was mainly necessary to rebuild moose and caribou populations that were much reduced by deep snow, hunting and predation. In 1975, the Nelchina Basin was considered to meet these criteria (Ballard et al. 1991) but the effects of experimental wolf control on the moose population were unclear (Ballard et al. 1987). Public harvesting of wolves primarily by LAS hunting did, however, keep wolf densities at low levels for prolonged periods. Although specifically excluded from the definition of wolf control by the Alaska Board of Game in 1982, this form of population management effectively duplicated the results of helicopter shooting by reducing wolves to about one-third of their unmanaged numbers.

Clearly, during the period 1950–1989 predators and prey in the Nelchina Basin were managed primarily to keep wolves low and ungulates high in order to benefit hunters. During the early years, public opinion favored severe wolf control measures, but strong opposition to bounties, poisoning and aerial hunting eliminated these practices by 1972. LAS hunting has drawn similar opposition in recent years and was prohibited during 1988–1990 but reinstated thereafter. The degree of control that humans can exert on wolves in this area is much reduced without LAS hunting because traditional forms of hunting and trapping are much less efficient.

Challenges to wildlife managers in the Nelchina Basin during the past 40 years have ranged from restoring a wolf population nearly extirpated by poison and aerial shooting to rebuilding moose and caribou populations that erupted and crashed. Future challenges will involve striving to keep ungulates high to maximize human harvests while achieving a better balance between wolf numbers, ungulate density and human harvests of wolves and ungulates. These are attainable goals but will require careful monitoring of predator and prey populations, habitat conditions and harvests. Moose numbers, now at levels approaching those preceding the crash of the 1960s, may decline during severe winters; it is unlikely that moose densities now exceeding 10 per square mile (4/km^2) in portions of the area (Ballard et al. 1991) are sustainable. Harvesting of female moose, necessary to keep the population from increasing, has been strongly resisted by the hunting public. The danger of a starvation-mediated moose decline is that moose densities may again reach the point where predation by bears and wolves limits recruitment and harvests, similar to conditions that prevailed in the mid-1970s (Ballard et al. 1991).

Wolves in the Nelchina Basin are perhaps the most difficult species to monitor without radiocollaring or intensive research projects. Track surveys are weather-dependent and difficult if large numbers of ungulates are present. Research is presently underway to improve aerial wolf population surveys; accurate data are needed to assess the status of wolves, determine the impacts of wolf harvests, and estimate the effects of wolf predation on moose and caribou.

Finally, Van Ballenberghe (1981) concluded that future wolf populations in the Nelchina Basin will depend on the integrity of the Basin's ecosystems, on attitudes toward wolves and wilderness, and on the relative degree of exploitation imposed on wolves and their prey. He noted that the last factor will likely remain dominant, similar to its importance in the past. In the intervening years little has occurred to change these conclusions. Managers in the future, however, will need to more closely integrate exploitation of wolves with society's expectations of balanced uses. Managers must re-evaluate the practice of keeping wolves at low densities for long periods if higher densities do not significantly reduce harvests of ungulates.

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Some Predictions Concerning a Wolf Recovery into Yellowstone National Park: How Wolf Recovery may Affect Park Visitors, Ungulates and Other Predators

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Introduction

On August 15, 1988, the U.S. Congress directed the National Park Service and the U.S. Fish and Wildlife Service to study questions and concerns about the proposed restoration of wolves (*Canis lupis*) into Yellowstone National Park. The study was to include but not be limited to "How a reintroduced population of wolves may affect the prey base in Yellowstone National Park and big game hunting in areas surrounding the park." The reintroduction of wolves may affect other species of predators or scanvengers. The park visitor experience might be reduced if viewing opportunities for ungulates were reduced, or if significant portions of parklands were closed to visitors access to protect wolf den sites. The purpose of this paper is to review the published literature and Yellowstone National Park records in an effort to answer the following questions:

1. What would be the prey of wolves?
2. Would wolves affect the demography, population size, distribution or behavior of park ungulates?
3. How would the park visitor experience be affected?
4. How would other predators be affected?

Description of Study Areas

Yellowstone National Park

Nearly all of Yellowstone National Park provides summer range for elk (*Cervus elaphus*) and other ungulates. The park is 79 percent forested, madeup of about 81 percent lodgepole pine (*Pinus contorta*) forests lying mostly between 7,544 feet (2,300 m) and 8,528 feet (2,600 m) in elevation (Houston 1982). In summer, elk concentrate near wet meadows, herblands on the higher plateaus, alpine tundra and a wide variety of forest openings (Meagher 1973, Houston 1982).

The high plateaus and ridges in Yellowstone receive up to 74 inches (190 cm) of precipitation annually, most of which falls as snow. Winter snowfalls force elk and other ungulates to leave most of the park's interior. Wintering ungulates occur on the Madison-Firehole/Mary Mountain, Thorofare, Pelican and Gallatin winter ranges (Figures 1 and 2) in addition to the most significant winter range—the northern elk winter range.

Yellowstone's northern elk winter range is defined as the area where elk from the

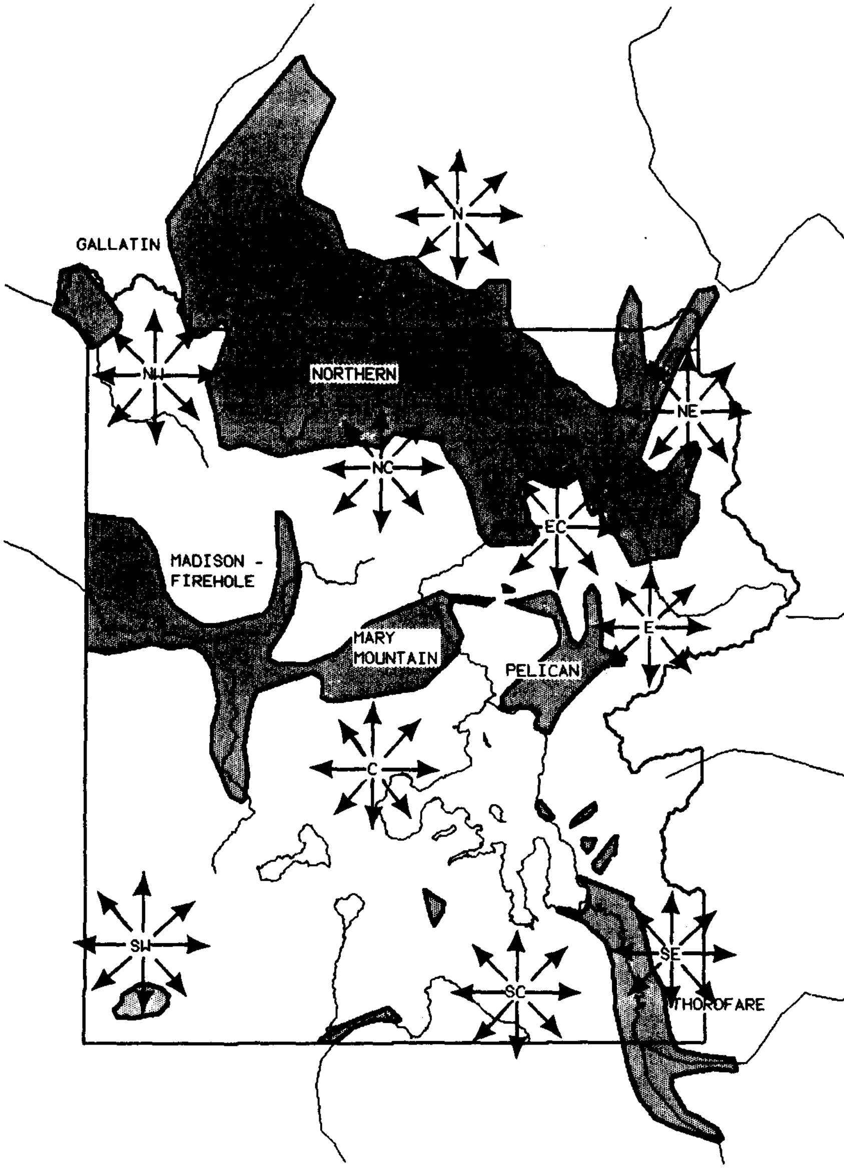

Figure 1. Winter ranges for ungulates within the boundaries of Yellowstone National Park. The approximate center of seven major concentrations for elk in summer are marked: NE (northeast) etc. All of Yellowstone National Park is occupied by some elk during summer.

Northern Yellowstone herd winter. About 82 percent of the northern range lies within Yellowstone National Park, and the remaining 18 percent lies outside of the park on national forest and private lands. Houston (1982) described the area as about 247,000 acres (100,000 ha) between Silver Gate and Dome Mountain, Montana (Figure 1).

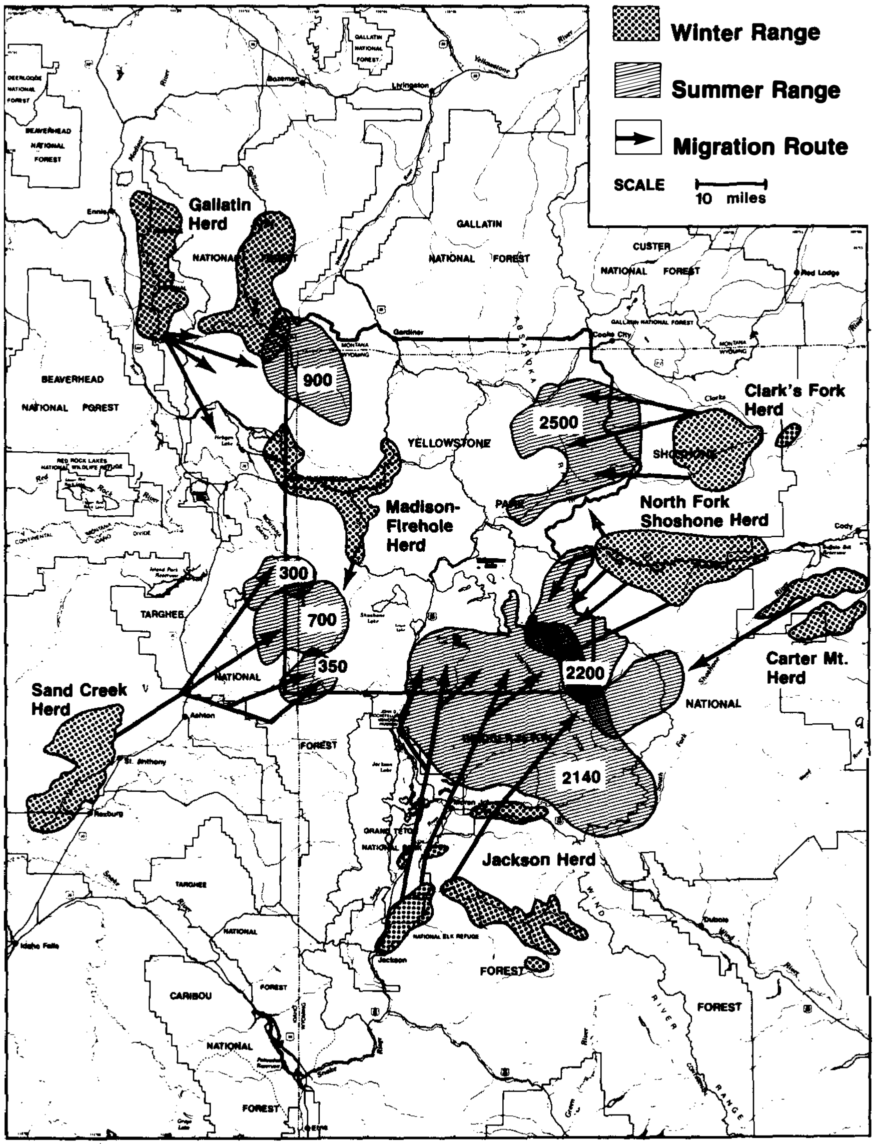

Figure 2. The approximate winter ranges and summering areas for seven elk herds, other than the northern herd, which use Yellowstone National Park. Approximate numbers of summering elk within Yellowstone National Park are included.

Elevations on the northern range are between 4,920 feet (1,500 m) and 7,872 feet (2,400 m). More ungulates winter in this area than on the higher plateaus of the park's interior (Meagher 1973, Houston 1982). The northern winter range is warmer and drier than the rest of the park (Houston 1982). Precipitation on the northern range varies greatly due to the considerable variation in elevation. Mean annual precipitation is 12 inches (30 cm) near Gardiner, Montana, but 22 inches (55 cm) near the Lamar Ranger Station 14 miles (35 km) upgrange. Most of the northern range averages 30 inches (75 cm) or less of total precipitation (P. Farnes unpublished data, Houston 1982).

Methods

Ungulate population data provided in Mack et al. (1990), Singer (1991), Meagher (in review) for the years 1980–1988 was summarized. Ungulate survey methodology is described in Meagher (1973, 1989), Houston (1982), Chu et al. (1989), Hurley et al. (1989), Lockman et al. (1989), and Singer (1991).

Results and Discussion

Ungulate Prey for Wolves

Typical average ungulate numbers and biomass on Yellowstone's northern winter range were about 18,500 ungulates or about 9.6 × 10^6 pounds (4.4 × 10^6 kg). (Table 1) during the period 1980–1988 including average counts of 17,458 elk, 600

Table 1. Average ungulate biomass pounds × 10^3 (kg × 10^3) on the winter and summer ranges of Yellowstone National Park for the period 1980–1988 (Houston 1982, Chrest and Herbert 1985, Chu et al. 1989, Hurley et al. 1989; Lockman et al. 1989, Singer 1991, M. Meagher personal communication). Biomass was calculated from live weights for Yellowstone National Park summarized in Houston (1982).

	Ungulate biomass (pounds × 10^3)						
	Winter ranges					Summer ranges	
	Northern range		Other park winter ranges				
	Within park	North of park and less available[a]		Total	Percentage total	Parkwide	Percentage total
Elk	7,786	882	944	9,611	74		82
Bison	525	0	2,273	2,798	22		15
Mule deer	11	212	4	227	2	350+[b]	2+
Moose[c]	123	tr	62	185	1	185+[b]	1+
Bighorn	26	11		~37	tr	42+	tr
Pronghorn	11	33	0	44	tr	59	tr
White-tailed deer and mountain goat	2	<7	0	<9	tr	<13	tr
Total	8,484	1,145	3,283	12,911	100	18,948	100

[a]Near the town of Gardiner, Montana, and outlying settlements where no sustained pack activity is predicted.
[b]Mule deer and moose are probably underestimated in summer.
[c]Population estimate from Houston (1982).

bison (*Bison bison*), 1,814 mule deer (*Odocoileus hemionus*), 392 pronghorns (*Antilocapra americana*), 273 bighorn sheep (*Ovis canadensis*), and an estimated 200 moose (*Alces alces*) (Houston 1982, Singer 1991, M. Meagher personal communication, Figure 3). Ratios of ungulate numbers on Yellowstone's northern range averaged 100 elk:10 mule deer:3 bison:2 pronghorn:1 bighorn sheep:1 moose. Ratios of ungulate biomass averaged 100 pounds (45.5 kg) elk:13.2 pounds (6 kg) mule deer:6.6 pounds (3 kg) bison:2.2 pounds (1 kg) moose:<1 bighorn sheep:<1 pronghorn.

Ungulate numbers on three other winter ranges within Yellowstone Park (Gallatin [partial], Madison-Firehole, Thorofare Creek) totaled about 4,500 ungulates or 3.9×10^6 pounds (1.8×10^6 kg) (Table 1) during the 1980s (Figure 3) including about 2,000 bison, 1,900 elk, less than 100 moose, and more than 30 mule deer (Singer 1991, M. Meagher personal communication). Ratios of ungulate numbers were 100 bison:95 elk:5 moose:1 mule deer for these areas. Ratios of biomass averaged 100 (pounds or kg) bison:42 elk:3 moose:trace mule deer.

Summer unglate population estimates for Yellowstone Park exceeded 37,800, with a total ungulate biomass equaling 19×10^6 pounds (8.6×10^6 kg.) (Table 1) for the years 1980–1988 average. Portions of eight elk herds migrate into the park each summer, totaling approximately 31,000 elk on the average from 1980 to 1988. Other ungulate population estimates for the same years were 2,500 bison, 100 white-tailed deer (*Odocoileus virgianus*), 100 mountain goats (*Oreamnos americana*), and 392 pronghorn. Approximate ungulate ratios in the park during summer were 100 elk:16 + mule deer: bison:3 + moose:3 bighorn sheep:1 pronghorn: < 1 white-tailed deer or mountain goat. Many more mule deer, bighorns and moose migrate into the park than previous counts indicated (Chu et al. 1989, Hurley et al. 1989, Lockman et al. 1989); therefore, their numbers are undoubtedly significantly underestimated.

Chest heights and foot loading suggested elk, mule deer, bison and pronghorns should be relatively vulnerable to wolves in deep snow, as would bighorn sheep when they occur away from escape terrain (Telfer and Kelsall 1984). Morphological indices, based upon foot loading and chest heights, rated the following species on their ability (from least to most difficulty) to move in snow: moose–140; wolf–135; elk–118; bighorn sheep–114; white-tailed deer–112; bison–95; and pronghorn–81. In general, wolves have an advantage in pursuit of ungulates during late winter when crusts form and wolves are supported better than their prey (Formosov 1946, Nasimovitch 1955, Mech and Frenzel 1971, Kolenosky 1972), but ungulates may have an advantage at other times (Mech 1970, Peterson 1977).

Where they occur together, wolves prefer mule deer over elk. Cowan (1947) reported that mule deer were killed 1.3 times more frequently than elk in Canada. White tailed deer where preferred over elk during average winters, but elk were preferred during a severe winter in northwest Montana (D. Pletscher personal communication). Wolves also prefer elk over bighorn sheep. In the Rocky Mountain national parks of Canada, bighorn sheep were killed only 0.17 times as often as elk, although they were 1.3 times more numerous (Cowan 1947). In another study, bighorn sheep provided only 3 percent of the year-round diet of wolves (Carbyn 1974a). Based upon relative availability, mule deer were killed 13 times more, elk were killed 0.28 times more, and bighorn sheep were killed 0.11 times more than the expected rate in winter (Carbyn 1974a).

Moose are killed less frequently than elk where the two species occur together.

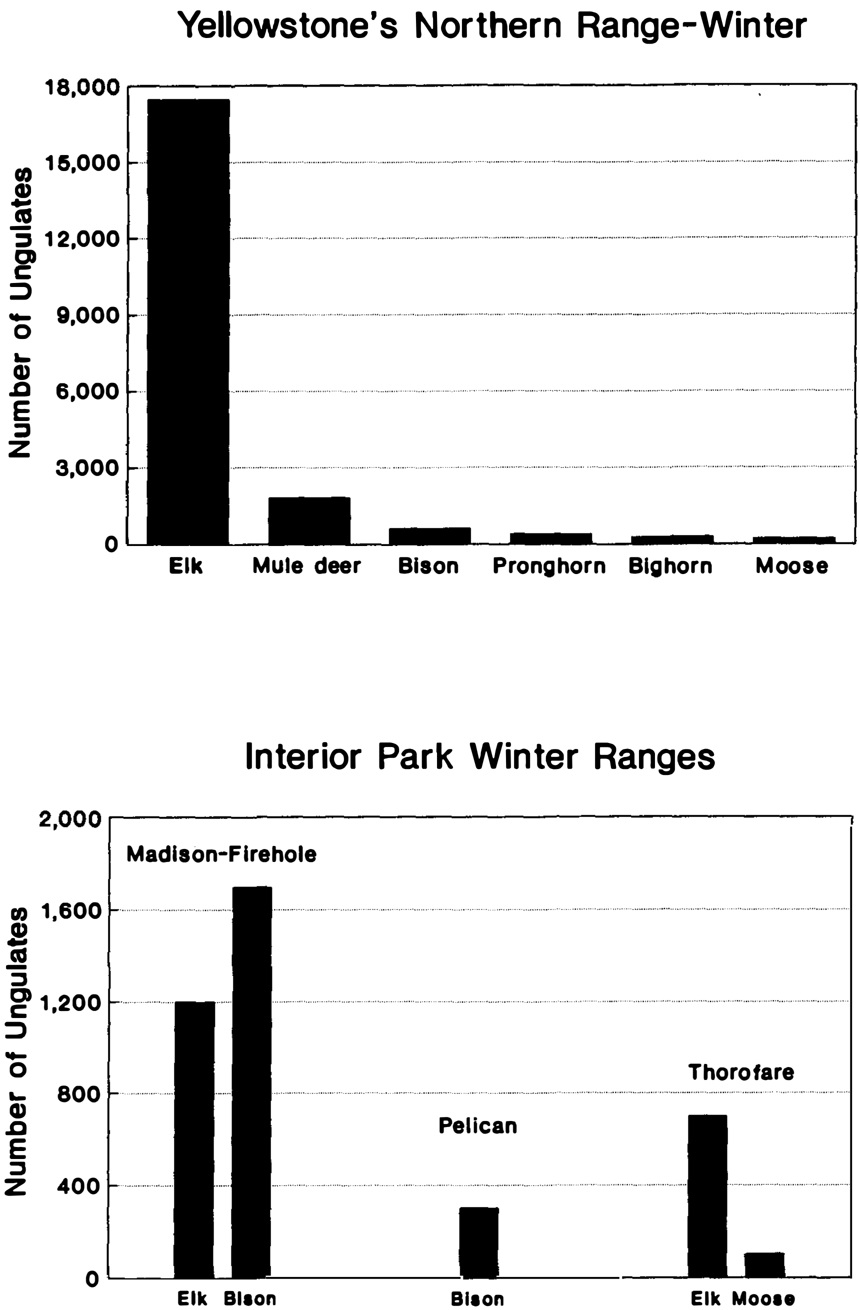

Figure 3. Numbers of native ungulates on the northern (top) and Madison-Firehole, Pelican and Thorofare (bottom) winter ranges in Yellowstone National Park. Numbers presented are averages of aerial counts, 1980–88.

In Riding Mountain National Park, Manitoba, there was one moose for every 10.5 elk, but wolves killed only one moose for every 15 elk (Carbyn et al. 1987). Elk are nearly as large as moose, but wolves cornered elk in one-sixth the distance of moose and, once cornered, elk were easier for wolves to kill (Carbyn et al. 1987).

The majority of mule deer on the northern range winter immediately north of the park, where extensive human occupation will likely reduce wolf activity. A few wolves may use this portion of the northern range, but reduced wolf pack activity is predicted since the townsite of Gardiner, Montana, occurs here, sport hunting activity extends over a four-month period, and many mule deer winter in the valley floor near human habitations.

The few white-tailed deer seen on Yellowstone's northern range are probably dispersers from nearby populations. Wolves will probably not reduce whitetails because no population winters within the park, and stable or expanding herds are at least 19.8 miles (32 km) away from the park's boundaries. These areas will probably not support any significant wolf activity (e.g., Tom Miner Basin, Rock Creek, Fall River, Upper Henrys Fork) due to proximity to human developments.

Pronghorn should be the most vulnerable park ungulate to wolves where they occur in snow (Telfer and Kelsall 1984), but Yellowstone' pronghorn winter on the outskirts of Gardiner, Montana, where snow depths are minimal, and wolves are predicted to avoid the area. Some pronghorn migrate into sagebrush-dominated higher valleys within the park each summer, where they could be taken by wolves.

Few observations of wolf predation are available from areas where bison and other ungulates occur together. Wolves are predicted to frequently pursue bison when bison are the most common, or the only ungulate species available. Wolves frequently pursued bison during the summer in Wood Buffalo National Park. Wolves approached, tested or rushed bison in 79 percent of all wolf-bison encounters (Carbyn and Trottier 1987, 1988). Historically, healthy bison of all age classes were relatively safe from attack by wolves during the early years of Yellowstone's designation (Meagher 1973). Bison should not be particularly vulnerable to wolves during winter on Yellowstone's northern range for the following reasons: (1) snow are shallower on the northern range than on the park's other two bison winter ranges (Meagher 1971, 1973); (2) elk, greatly outnumber bison (100 elk:2 bison); (3) bison groups are scattered throughout the northern range; (4) bison fend off wolves as a group, and bulls are very aggressive towards wolves; and (5) bison calves are protected by their position in bison pods and calves can withstand prolonged attacks by wolves (Carbyn and Trottier 1987, 1988).

Bison will be killed by wolves in the Madison-Firehole/Mary Mountain area since bison are more abundant than elk (100 bison:95 elk) and in the Pelican Valley where only bison occur. Telfer and Kelsall's (1984) chest height and foot loading analysis suggests that bison would be vulnerable to wolves in deep snow. Oosenbrug and Carbyn (1983) reported that solitary bison are most vulnerable to wolves. They reported that a pack of wolves killed one bison every eight days in winter including a high proportion of adult males in Wood Buffalo National Park, Alberta. Van Camp (in Oosenbrug and Carbyn 1983) reported that a large pack of wolves killed one bison every seven days in the Slave River lowlands, and 86 percent of these were cows or calves. Apparently wolves suppressed bison recruitment in the Slave River lowlands, although hunting, disease and severe winters also contributed to the decline. In both studies, bison were the primary prey available. In conclusion, wolf effects on bison would likely range from relatively minor on the northern range, to more significant on the Mary Mountain and Pelican Valley ranges.

Based on ungulate vulnerabilities to wolves from the literature and knowledge of ungulate distributions, I predict, if elk vulnerability was set at 1.0, mule deer vulnerability to wolves would be 1.3, pronghorns 1.0, bison 0.7, moose 0.7 and bighorns 0.3. For every 100 elk killed by wolves on the northern range, I estimate 24 deer, 2 moose, trace bighorn, 2 bison, 0.7 moose and 2 pronghorns would be killed by wolves. For every 100 elk killed on the other winter ranges, I estimate 74 bison and 4 moose will be taken by wolves. Wolves killed mostly young of the year and older-than prime-age adult elk (Carbyn 1983), moose (Mech 1966, Pimlott et al. 1969, Peterson 1977), Dall sheep (*Ovis dalli*) (Murie 1944) whitetails (Pimlott et al. 1969, Mech and Frenzel 1971) and caribou (Kuyt 1972). Wolves killed more adult male than adult female ungulates (Pimlott 1967, Mech and Frenzel 1971, Carbyn et al. 1987, Haber 1977, Oosenbrug and Carbyn 1983).

Wolf Packs and Territories

The opportunity apparently exists for five to six year-round wolf pack territories of approximately 34.7–57.9 square miles (90–150 km^2) on the northern range. About 2,000–4,000 elk winter only 3.7–25.8 miles (6–16 km) from summer ranges in the following areas: (1) Cache Calfee/Mount Norris (NE); (2) Mirror Plateau (EC); (3) Buffalo Plateau-Telephone Basin (N); (4) Garners Hole-Gallatin Mountains (NW); and (5) Cook-Folsom Peaks (NC) (figure 1). Perhaps another two to three packs could establish much larger territories of less than 289 square miles (>750 km^2) that include portions of the northern range and elk summer ranges, 13–51.6 miles (21–32 km) from the northern range such as the following areas: (1) Pelican Valley (EC); (2) Upper Lamar (E); and (3) Hayden Valley-Bridge Bay (C) (Figure 1). Single packs could establish year-round territories in the Madison-Firehole/Mary Mountain area (1,300–1,700 bison, 800–1,400 elk in winter) and possibly the Upper Yellowstone River-Thorofare area (100 moose, 500–700 elk in winter) (Figure 2), although the Thorofare area appears marginal for sustained winter wolf pack activity.

Four additional summer concentrations of elk occur in the park—Southwest (SW)–1,400+ elk, Southeast (SE)–2,200+ elk, South-central (SC)–2,000+ elk, and the Central Plateau (C)–7,000–10,000 elk (Figure 1). Elk migrate 77–103 miles (48–64 km) from these areas to winter ranges (Brown 1985, Boyce 1989, D. Vales personal communication, Smith and Robbins personal communication). Fewer than 100 ungulates winter in each of these locales suggesting any wolf packs using the areas would have to migrate each winter. Wolves migrate 135–257 miles (80–160 km) between summer and winter caribou ranges in Alaska (Stephenson and James 1982), and as much as 223 miles (360 km) between caribou seasonal ranges in the Northwest Territories (Kuyt 1972). However, no intance of migratory wolves south of the arctic or boreal forest regions are reported.

In conclusion, seven to nine wolf packs with fixed territories could occupy Yellowstone's northern range; another one to two fixed packs could occupy the park's other winter ranges; and another three to four packs might be supported, but only if the latter were migratory or semimigratory (total = 11–15 packs).

If each wolf pack plus loners averaged 10 wolves, this equates to 110–150 wolves for Yellowstone National Park. Biomass available would range from 126,595 to 172,632 pounds (57,426–78309 kg) per wolf during summer (110–150 wolves) and from 129,118 to 161,398 pounds (58,570–73,213 kg) per wolf during winter (80–100 wolves). Winter densities of wolves are predicted to be 1 wolf per 4–31 square miles (1 wolf/40–80 km^2) (10–20 wolves) on the other park ranges. Summer densities of wolves parkwide would be 1 wolf per 23–31 square miles (60–81 km^2) (110–150 wolves). If these scenarios hold true, winter densities of wolves on the northern range would be among the highest recorded (Mech 1970, Kuyt 1972, Van Ballenberghe et al. 1975), with biomass per wolf among the highest (Mech 1970, Keith 1983). Mech (1970) reported 1 wolf per 10 square miles (1 wolf/26 km^2) appeared to be a maximum density, although concentrations of 1 wolf per 4–6 square miles (1 wolf/10–15 km^2) have been observed (Kuyt 1972, Van Ballenberghe et al. 1975). Mech (1970) advanced the idea that when prey biomass exceeds 24,200 pounds (11,000 kg) of prey per wolf, wolf predation cannot be considered a primary controlling influence on prey densities. However, Theberge (1990) cautioned that wolf/prey ratios be used in preliminary assessments only.

Ungulate Distribution after Wolf Recovery

Adult female ungulates with young calves may alter their habits more than other ungulate sex and age classes after wolf recovery. Cow moose with young calves frequent wolf-free islets within Isle Royale National Park and consume a poorer quality diet than cows without calves or yearlings (Edward 1983). Moose cows with young calves frequent camps occupied by people, or human developed areas, apparently to avoid large predators (Stephens and Peterson 1984, E. Bangs personal communication, J. Dalle-Molle personal communication). Caribou (*Rangifer caribou*) cows with young calves demonstrate similar strong antipredator strategies (Bergerud 1980, Bergerud et al. 1984) including isolation of cows with calves on island or high slopes where they consume poorer quality diets. Cows with calves skirt willow (*Salix* spp.) thickets, apparently to avoid ambushes by predators (Roby 1978) while bulls prefer the thickets for feeding. Newborn ungulates in Yellowstone Park are preyed upon by coyotes and grizzly bears (Robinson 1952, French and French 1990), so adult female ungulates may already exhibit antipredator behavior. Several antipredator strategies appear instinctive, such as hiding calves and fawns (Carbyn 1974a), traveling to separate calving areas (Bergerud 1980), and winter yarding behavior (Messier and Barette 1985).

Adult ungulates may change their use of habitats slightly in response to wolves. Wolf researchers report little movement by groups of ungulates after wolves test or kill individuals (S. Fritts, L. Carbyn personal communication). Bighorn sheep stayed closer to steep, escape terrain in Jasper National Park after wolves reoccupied the area following a rabies control program (J. Stelfox personal communication). Ungulates occupying the fringes of winter concentrations are preyed upon more intensely by wolves (Fritts and Mech 1981, Nelson and Mech 1981, Messier and Barette (1985), and they may respond more to wolf presence. Hatter (1982) reported elk cow-calf groups on Vancouver Island increased summer range movements when wolf densities were high; elk preferred forest habitat, and black-tailed deer (*Odocoileus hemionus peninsulae* by passed spring ranges. Landscape features such as heavy timber downfall, cliffs and open water may provide escape opportunities for elk and moose (Peterson and Allen 1974, Gunson 1986). Remnant populations of ungulates may respond more to wolves (Ferguson et al. 1988). Few studies, however, specifically addressed changes of habitat use by ungulates in response to wolves, so some responses may have gone undetected.

Small populations of ungulates inhabit the thermal areas of Yellowstone National Park's interior during winter. In 1987–1989, one or two bull bison wintered at Little Firehole Meadows, and groups of 10–25 elk wintered at each of the following areas: West Thumb Geyser Basin, Shoshone Geyser Basin, Basin Creek and Heart River Hot Springs. Near Old Faithful, four to six mule deer wintered, and, at Heart Lake Geyser Basin and the Bechler Meadows thermal areas, groups of 25–30 elk wintered. Both wintering elk and bison are common in the Gibbon, Firehole and Madison Rivers, and bison are found along Pelican Creek thermal areas (Craighead et al. 1973, Meagher 1973). Geothermal activity possesses shallower snows and greater access to forage. Forage grows all winter in warm meadows and along warm watercourses (Craighead et al. 1973). Deep snows surround all of the thermal areas of the park's interior.

Ungulates inhabiting the larger thermal areas of the park are predicted not to be particularly vulnerable to wolves during winter. Just as whitetailed deer escape from wolves in winter yards by running along any of the many crisscrossing beaten trails (Nelson and Mech 1981, Telfer and Kelsall 1984), park ungulates could escape from wolves on the relatively snow-free surfaces of the larger thermal areas.

Ungulates inhabiting the very smallest thermal areas during winter, consisting of only a few hectares or more could be reduced by wolves, since wolves could easily chase the ungulates into deep snows bordering the thermal areas. Population consequences would be insignificant since 4 percent of the elk and more than 10 percent of the park bison inhabit small thermal areas.

Wolf Effects on Ungulate Populations

If one wolf kills an average of 13 elk-sized ungulates per year (Mech 1971, Fuller 1989, Carbyn 1983, J. Gunson personal communication), then 80 wolves are predicted to kill approximately 1,040 northern range ungulates per year. This ungulate total would include 794 elk, 191 mule deer, 16 each of bison, moose and pronghorns, and 2 bighorns.

Wolf predation may result in slightly lower densities, younger age structure and higher reproductive rates (= compensatory production) in unhunted park populations of ungulates. The Northern Yellowstone elk herd, for example, is characterized by low calf/cow ratios in the absence of wolves (Houston 1982, Singer 1991). The timing and proximate cause of elk deaths will differ after wolf recovery. Winterkill of ungulates will decline.

Wolf Effects on Other Predators

Coyote. Coyotes (*Canis latrans*) may be impacted by a wolf reintroduction. Few closely parallel examples exist, but coyotes probably will be less abundant in Yellowstone after wolf recovery since wolves frequently kill coyotes (Seton 1929, Young and Goldman 1944, Munro 1947, Stenlund 1955, Berg and Chesness 1978, Carbyn 1982). Coyotes were extirpated by wolves on Isle Royale (Mech 1966, Krefting 1969, Allen 1979). Coyotes expanded into several areas of North America after wolves disappeared (Silver and Silver 1969, Mech 1970) suggesting wolves suppressed coyotes. High densities of wolves in northeastern Minnesota, 1 wolf per 10 square miles (26 km^2) may have prevented coyote colonization of that region (Berg and Chessness 1978). In northeastern Alberta, coyotes tended to live primarily along wolf pack territory edges where the chance of encountering wolf packs was the lowest (Fuller and Keith 1980).

Wolves and coyotes historically coexisted in Yellowstone National Park (Murie 1940) as they do in the Canadian Rocky Mountain national parks (Cowan 1947, Carbyn 1974b) and in Riding Mountain National Park (Carbyn 1982, Paquet 1989). Some competition between coyotes and wolves was reported from Riding Mountain National Park (Carbyn 1982). Coyotes avoided wolves more in mid to late winter when food was limiting than in early winter, and coyotes became rare after a period of relatively high wolf populations (Carbyn 1982). However, Paquet (1989) observed no spatial segregation between the two species. Coyotes did not avoid areas frequented by wolves, and although wolves occasionally killed coyotes, coyotes often trailed wolf packs at a safe distance. Wolves killed more elk than mule deer, but coyotes killed mostly deer and an occasional elk. Most coyote use of elk was scavenging of wolf kills. Paquet (1989) concluded that sympatric populations of wolves and coyotes existed where multiple species of ungulates occur and where the primary prey of wolves was larger ungulates such as moose, elk or bison. Where deer are the key prey species for wolves, as is the case in Minnesota, the degree of dietary and ecological overlap increases. Less scavenging potential exists for coyotes, since wolves that kill deer leave few remains. Coyotes kill deer at all times of the year in Yellowstone National Park (Murie 1940, Robinson 1952), but Yellowstone National Park supports a multiungulate prey base, and elk, not deer, will be the key prey for wolves. Therefore, it is predicted that coyotes would not be extirpated in Yellowstone.

Red fox. Red fox (*Vulpes vulpes*) are rare in Yellowstone National Park, but their numbers are predicted to increase following wolf recovery. Wolves occasionally kill foxes (Stenlund 1955, Mech 1966, Banfield 1974), and wolves typically chase foxes off carcasses, but foxes usually remain in the area until the wolves finish feeding (Magoun 1976). Peterson et al. (1982) reported that foxes usually are able to escape from wolves. Foxes largely benefit from wolves. During a period when snowshoe hares (*Lepes americanus*) were not abundant, the carrion from wolf-killed moose sustained red foxes on Isle Royale (Johnson 1970). Mech (1970) concluded that foxes mostly benefit from abandoned wolf kills, although he observed that both species robbed each other's food catches.

Any reduction in coyote numbers due to wolf recovery should benefit foxes. The presence of coyotes limited the habitat available to foxes in eastern Main (Harrison et al. 1989). There, foxes were usually associated with riparian areas of lakeshores, but foxes did not use those habitats within coyote territories. Foxes established home ranges outside coyote territories or in boundary areas between coyote groups.

Wolverine. Wolverines (*Gulo gulo*) are killed by wolves, but Yellowstone National park is so extensively forested (79 percent) that wolverines could escape from wolves by climbing trees. Three instances of wolves killing wolverines have been reported (Burkholder 1961, Boles 1976), but in each case, tree escape was not possible. Murie (1963) observed three other attacks by wolves upon wolverines, but the wolverines escaped by climbing trees. Wolves and wolverines coexist over large regions of northern Canada and Alaska, including treeless areas.

Mountain lion. Mountain lions (*Felis concolor*) and wolves would likely overlap to some extent inhabitat use and food habits. Wolves killed two mountain lions in Glacier National Park, Montana (D. Pletscher personal communication). Little published information exists on population effects on either species.

Black bear. Black bears (*Ursus americanus*) can become prey for wolves, although the heavily forested nature of Yellowstone National Park suggests black bears could escape to trees in most nondenning situations. Wolves have been observed to chase black bears (Rutter and Pimlott 1968), to tree black bears (Rogers and Mech 1981) and, in one instance, to kill a nondenning black bear (Young and Goldman 1944). Five instances were reported of wolves digging up, killing and consuming denning black bears (Rogers and Mech 1981, Horejsi et al. 1984, Paquet and Carbyn 1986). Cubs were present in two cases—in one instance, the cubs were killed; and, in the second instance, the cubs escaped by climbing a tree. The cubs of any bear species may be vulnerable in treeless areas. Wolves killed one of two polar bear (*Ursus maritimus*) cubs after separating one cub from the sow (Ramsay and Stirling 1984). Black bears might avoid treeless areas more in Yellowstone National Park after wolf reoccupation, but black bears may already avoid treeless areas due to the presence of grizzly bears.

Black bears have been observed to chase single wolves (Rogers and Mech 1981) and, in one case, a black bear killed an adult female wolf (Joslin 1966). Black bears usurp wolf kills (Mech 1970) as do grizzly bears (Murie 1981, Hornbeck and Horejsi 1986), but wolves may also usurp bear kills (Haber 1977, Ballard 1982).

Grizzly bear. A review of the possible effects of introduced wolves on Yellowstone grizzly bears suggested few effects on population numbers from wolf-bear interactions (Servheen and Knight 1990). Direct interactions, most of which were confrontations over food or young, appeared to favor neither species on the average (Servheen and Knight 1990). A few highly predatory Yellowstone grizzly bears could be influenced by wolf reintroduction, but Servheen and Knight (1990) predicted any changes would be gradual with increasing wolf numbers, and bears would adapt.

Effects on Yellowstone Park Visitors

Viewing opportunities for ungulates are predicted to decline little, if at all, after wolf reintroduction. Elk populations may decline 15 percent–25 percent, and bison populations may decline 5 percent–15 percent after complete wolf recovery (Boyce 1990, Koth et al. 1990), thus reducing the total number of ungulates to observe. Few habitat or distribution changes are predicted except by adult female ungulates with young. Ungulates that frequent human developments should continue to be highly observable to visitors since these areas will be avoided by wolves (Stephens and Peterson 1984). Ungulate use of human developments may even increase after wolf reintroduction.

Wolves are typically shy animals that usually avoid humans where harvest by humans exists. Some wolves lose their fear of humans, such as where they frequent human garbage sources. Even after 40 years of total protection, Isle Royale wolves still exhibit fear of man similar to that in a hunted population (Peterson and Morehead 1980). Yellowstone Park wolves are predicted to be similarly shy.

Humans may disrupt wolf activity, particularly near den sites. Fewer wolf kills of ungulates and four deserted wolf dens occurred in areas near human developments in Jasper National Park, Alberta (Carbyn 1974b). Wolves howled, left the area and/or moved pups when disturbed at den sites (Haber 1968, Chapman 1979). However, low intensity disturbances did not cause significant pup mortality (Chapman 1979).

Management actions to protect wolves in U.S. national parks have varied considerably. Chapman (1979) recommended prohibiting human access within a 1.5–miles (2.4–km) radius of den sites and active rendezvous sites. He recommended closures lasting from four weeks prior to whelping until 1 August. To protect the location of den sites from visitors, Denali National Park staff closed eight areas averaging 16.2 square miles (42 km^2) range 3.8–38.6 square miles (10–100 km^2) to protect wolf packs. These closures are irregularly shaped rather than concentric to prevent visitors from predicting the den locations (J. Dalle-Molle personal communication). In 1989, Denali National Park reduced the number of wolf closures from eight to four, but their size was increased to a mean of 38.6 square miles (100 km^2) range 20.8–72.2 squaremiles (54–187 km^2) (T. J. Meier personal communication). The larger closure size in 1989 was used partially to coordinate with backcountry units and with bear closures. In 1990, only areas with active dens will be closed.

The smallest wolf closures are used in Voyageurs National Park where closures around active dens are circular and 0.5–0.9 miles (0.8–1.6 km) in radius. Voyageurs National Park managers restrict dogs and dogsled teams to the open ice areas of the park, attempt to increase public awareness of wolves, and work to increase prey abundance and diversity. Park managers are considering reintroducing caribou and possibly elk. Isle Royale National Park has been closed to winter use by visitors since 1975, largely to reduce disturbances to wolves and to reduce interference with long-term research (Peterson and Morehead 1980). Plans to build a new shoreline trail were dropped to protect wolves. The park is delineated into 46 travel zones, averaging 4.5 square miles (11.8 km^2). These zones are closed temporarily for active wolf dens, active wolf rendezvous sites or other intense wolf activity. The zones are reopened as soon as wolves leave the area. Visitor activities in Glacier National Park, Montana, have been affected little by wolf activity. Two road sections have been closed for a few weeks during the beginning of the visitation period, but the sections were opened as soon as wolves moved pups from den sites (W. Brewster personal communication). It may be necessary to close a few small areas in Yellowstone Park during denning by wolves. Some wolf denning should take place in existing bear management areas or remote areas where no further action would be necessary. Most closures near wolf dens in the U.S. national parks last from denning, about 1 April, until the pups are moved, usually about mid-June.

A number of unanswered questions surround the proposed wolf reintroduction into Yellowstone. Will some wolves be migratory? Will wolves learn to take bison? How will wolf predation affect the demography of the ungulate herds? These questions can only be answered after wolves are reintroduced into the Yellowstone National Park area.

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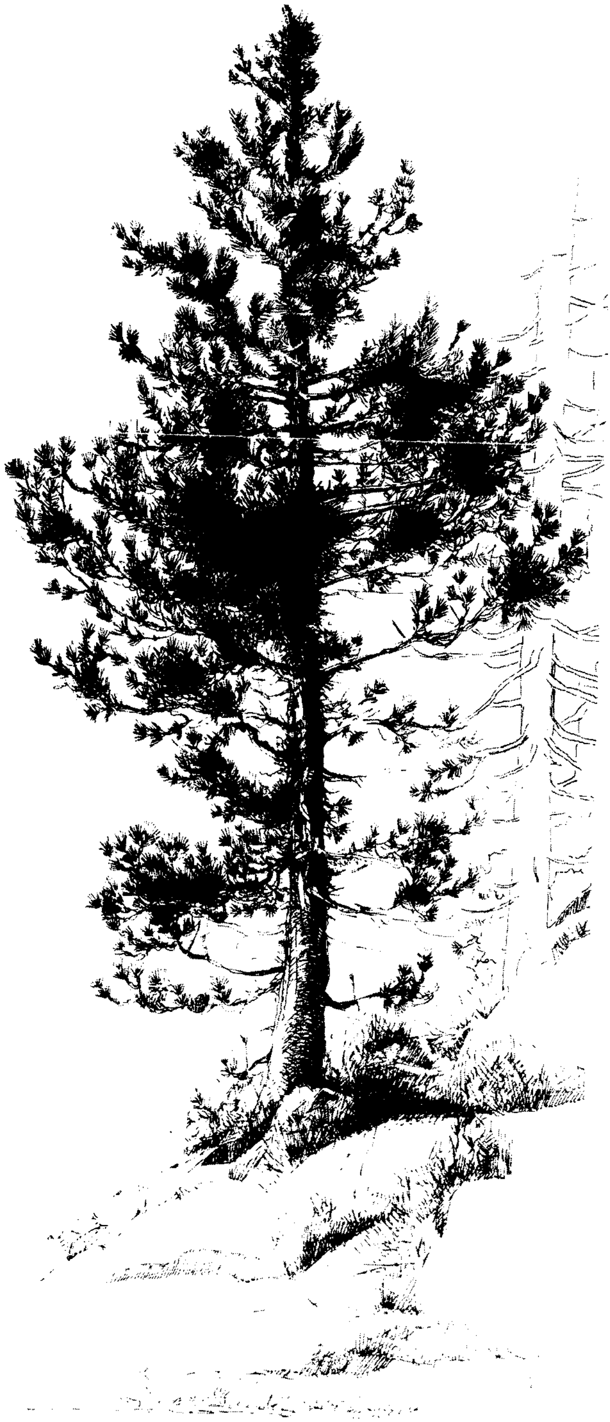

Special Session 10. *Forest Management for the Future*

Chair
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Opening Remarks

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Forest management has passed through many turbulent phases since its genesis in medieval Europe. At first, foresters were little more than protectors of the King's stags, but by the 16th century they had begun to learn how to harvest and replace crops of timber and fuel wood (Heske 1938, James 1981). The Industrial Revolution and subsequent mechanization expanded both the available timber supply and the rate at which it could be depleted. Exploration and settlement of new territory, especially in North America, revealed new species, ecosystems and terrain that bred many innovations. Through these steps, forestry has grown, if not into a "mature" profession, at least to be a vibrant youngster with boundless energy and ideas. Yet in view of coming events, the past appears to have done little but dispel the innocence of youth. North American forest managers will face more new challenges in the next 50 years than in all their history.

This is no slight of the historical achievements of forestry, for there is much to celebrate. But the scale and scope of forest management challenges are now expanding tremendously. Of course, consideration of multiple geographic scales has long been part of the forester's business. Where site-specific decisions once concerned well-bounded issues such as road-location logistics and regeneration techniques, however, they now often involve difficult concepts like long-term soil productivity and biological legacies. Where allowable cuts were the main regional issue, landscape ecology and sustainable development for local economies now intrude. And where international timber demand and supply once dominated the forester's international perspective, global climate change and acidic deposition threaten massive new problems.

To deal with these new concepts, human desires and problems, it is likely that all forest managers will have to change their ways to some degree. Change comes at different times and different rates to different people, in forestry as in all else. After recent debates over wilderness, old growth, spotted owls and New Forestry, few foresters in the northeastern United States and the Pacific Northwest would claim now, as many might have only 10 years ago, that forestry is a technical discipline concerned first, foremost and always with the growing of timber crops for human use. On many privately-owned lands and on some Canadian public lands where pressures for non-timber uses have been less intensive, however, there are still foresters who subscribe to that narrow definition of the discipline. As awareness of environmental concerns grows throughout the continent and unexploited forest resources shrink, even the most conservative of managers will soon have to adapt.

This Special Session highlights some of the major trends and problems that will compel such adaptation. It includes a wide range of papers that together should help to crystallize some of the spectral visions that have been sketched for us by modelers, researchers, and futurists. In just three hours, it is not possible to review all of future forestry's prospects. Therefore, we have structured the agenda to cover critical forest management issues at a range of scales from global to site-specific, picking what we consider to be important problems or trends at each level.

Through self-improvement, imagination, dedication and patience, professional managers of forest lands and resources must rise to meet these challenges. The alternative—to relinquish responsibility to vocal but unqualified critics, with or without a fight—would benefit neither society nor the environment. As they have had to do on many occasions in times past, forest land managers must now check their vests for trusted tools and manuals, listen to the wishes of their clients, and lift their eyes to new horizons. Here are some of the vistas they will see.

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North American Forests and Global Climate Change

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Introduction

Global climatic change has long been recognized as one consequence of discharging large quantities of radiatively active gasses into the atmosphere. These gasses (CO_2, CH_4, CFCs, and N_2O) are being released as a result of human activities such as fossil fuel burning, deforestation, and chemical production. Although there has been and will continue to be considerable debate about the rate of climatic change in response to these changes, consensus is emerging among a large group of scientists that global climate will respond to the ongoing changes in atmospheric composition (Shine et al. 1990).

Forests in North America grow for many decades to reach maturity. If climatologists and atmospheric scientists are correct, the predicted climatic change will occur well within the lifetime of trees planted today. Moreover, most of today's existing forests may also be affected by climatic changes. What will the implications be for resource managers? Do they need to be concerned now and what are the options for adaptation and mitigation? If managers decide not to act, how do they know when the time for action has come? What are the information requirements in light of the long planning horizons in forest management and the traditionally high degree of uncertainty?

In this paper, we will provide a brief overview of the predictions of climatic change and the current understanding of forest response through changes in growth rates, disturbance regimes, and species composition. We will explore the implications of these hypotheses to resource managers and suggest an approach to developing response strategies.

Climate Change

One major component of current climate is the balance between solar radiation entering the earth's stratosphere and the outgoing thermal radiation. Radiatively active gasses allow the passage of short wave radiation through the earth's atmosphere, but absorb and reflect some of the thermal energy of long wave radiation that is reflected from the earth's surface back toward space. The concentration of such gasses in the atmosphere is, therefore, one important component of the global energy balance. The concentration of many of these gasses fluctuates naturally, as do many climate variables, but the concentrations have increased significantly since industrialization (Boden et al. 1990, Shine et al. 1990).

Climatologists have developed computer models predicting several consequences of the observed and predicted future increase in radiatively active gasses. To facilitate computations, it is often assumed that future atmospheric concentrations of CO_2 (and other gasses expressed in CO_2 equivalents) will reach double the pre-industrial levels. There is no evidence, however, that a doubled concentration of CO_2 would be a new stable equilibrium, and it should therefore be regarded as a transient concentration which can be reached and exceeded unless mitigative action is taken.

The consensus among climate modellers is that temperatures will get warmer and precipitation patterns will be altered (USEPA 1989, Mitchell et al. 1990). Predictions for central North America are temperature increases of 2–4°Celcius by 2030 and summer soil moisture decreases by 15–20 percent of the present value (Mitchell et al. 1990, Manabe and Wetherald 1986). Even greater changes in temperature and summer soil moisture are predicted for Canada. Rates of climate change are predicted to be one or more orders of magnitude faster than those experienced during the past millennia. Little is known about the transition from the current to future climatic conditions, but increases in extreme events cannot be ruled out (Mitchell et al. 1990).

Uncertainty about these climate predictions is attributed to the incomplete understanding of the climate system and its many feedback mechanisms. Some potentially important processes may not be included in global circulation models, but there does not appear to be a consistent bias, because some of the uncertain and omitted processes could further increase the predicted changes while others could act as buffers.

In summary, climate change is real, and although uncertainties remain about the exact timing and regional expression, those uncertainties are, in the authors' opinion, no justification for continued inaction.

Forest Responses

The response of North American forests to climatic changes can be described at various spatial and temporal scales. For this discussion, we are describing three categories of response from which inferences about management implications can be derived. We will discuss forest response in terms of changes in growth rates, disturbance regimes, and species composition, and we will emphasize regional differences where appropriate.

Growth Rates

Growth rates at any site reflect the trees' ability to obtain resources such as nutrients, moisture, temperature, light, and growing space. Tree growth rates are generally limited by one or more of the required resources. The most limiting resource often differs between forest regions. Within any region, site and season introduce further variation.

Global climatic change is predicted to alter temperature and moisture regimes: temperatures are predicted to increase while soil water deficits will become more pronounced in many parts of North America (Manabe and Wetherald 1986). Photosynthesis, respiration, and nutrient cycling are all affected by changes in climatic conditions. In many forest ecosystems, climate change will alter the resource constraints on tree growth: the response of growth rates will depend on the current resource limitations and their change in the future. If global climate change occurs within the context of altered atmospheric conditions, both in terms of carbon dioxide or other gasses and pollutants, tree growth may be altered in ways—some positive, some negative—that are inter-related and difficult or impossible to predict at this time.

Soil moisture deficits are already important in limiting tree productivity in many parts of western North America (Robertson et al. 1990). Increased temperatures will lead to greater potential evapotranspiration and greater soil moisture deficits unless precipitation also increases. Some studies suggest an increase in water use efficiency as a result of greater atmospheric CO_2 concentrations (Eamus and Jarvis 1989), but there is little evidence to suggest that this increase will be sufficient to maintain current tree productivity at greater soil moisture deficits. In areas where soil moisture is already limiting tree growth, warmer and drier conditions may lead to further reductions of productivity.

Low temperature is limiting tree growth in many boreal and high elevation ecosystems. Temperature directly affects photosynthesis and respiration. Low temperature indirectly affects tree growth by slowing decomposition processes and limiting nutrient availability. Where moisture is not limiting, temperature increases can lead to greater productivity. The increases could be more pronounced if higher CO_2 concentrations further increase growth rates, as has been observed in short term experiments with tree seedlings (Bazzaz et al. 1990).

Natural Disturbances

The area annually burned by wildfires is highly correlated with climatic conditions which affect fuel moisture and provide ignition sources (lightning). In sparsely populated areas of Alaska and the Canadian North, where commercial timber values and the risk of fire to human settlements are low and access is often difficult, fire suppression policies are such that drier and warmer conditions generally lead to greater areas burned annually. For example, the ten-year running average of the area annually burned in Canada increased from about one million ha in the period 1950–1970 to 2.5 million ha in the late 1980s (van Wagner 1988, personal communication), a decade marked by a series of warm and dry years. In the very dry and warm year of 1989, over 7 million ha burned in Canada.

Fire suppression policies in the contiguous United States, along with the vast differences in annual weather patterns across the continent, tend to reduce the immediate effects of extreme climatic events on annual fire statistics. There are still connections, however. For example, in the years 1972 through 1983, there were six years in which the average annual temperature for the U.S. was above the mean for the period (Boden et al. 1990). In five of those years, fire fighting expenditures were also at or above average, when compared on an inflation-adjusted scale (USDA 1989). It seems reasonable to postulate that regional comparisons would yield a closer correlation, but those comparisons have yet to be completed.

Insect populations are affected directly by climatic conditions and the predicted increases in temperature may lead to expansions of the population size and range of several insect species. Climatic change may also increase tree stress, specifically drought stress, in many forest ecosystems, thus increasing the vulnerability to insect attacks. As with fire, increased pest management efforts may mask the impact of climate change on pest populations.

Windthrow problems may increase if storm events increase or storm tracks shift as a result of climatic changes. This is of particular concern in the eastern United States, where hurricanes periodically devastate forest lands.

Species Composition

Changes in growth rates and disturbance regimes will each contribute to shifts in species composition. As ecosystem resource constraints shift in response to altered climatic conditions, plant communities will evolve from their current species composition towards some new composition for which current analogues need not exist. Differing responses to increased CO_2 concentrations between C^3 and C^4 plants and between tree species may further contribute to shifts in species composition (Bazzaz et al. 1990).

Increases in winter temperature will differentially affect deciduous and non-deciduous trees. Conifers growing on the west coast already experience winter conditions adequate for photosynthesis. Winter temperature increases may further improve the competitive status of evergreen conifers relative to deciduous hardwoods by increasing the proportion of annual photosynthesis which occurs when deciduous trees and shrubs are without leaves. If winter temperatures are too high, however, chilling requirements for bud-burst in some conifers may not be met (Cannell and Smith 1986).

Fire and insects will also affect ecosystem species composition. In many temperate and boreal forests, hardwoods are the pioneer species which first colonize disturbed sites. Increases in fire regimes may lead to regional changes where forest communities shift toward species which can effectively colonize burnt areas or those that can withstand periodic fires. Many of North America's forest ecosystems are adapted to fires and have developed seed storage and dispersal mechanisms to recolonize after fire disturbances. Increases in fire frequencies may, however, reduce the period between successive fires to the point that the post-disturbance communities have not reached the seed producing stage when the next fire kills the stands. The community which emerges after repeated fire is dependent on residual seed and bud banks and on wind dispersed seeds of hardwoods and grasses from seed sources outside the burnt area. In dry areas, the combination of increased fire frequency and greater soil moisture deficits may lead to shifts in ecosystem structure from forest to brush or grassland conditions.

Migration of species in response to shifts in climatic conditions are well documented (Davies 1981, Webb 1987). Historic migration rates of tree species, derived from fossil evidence for North American trees, range from 10–45 km per century (Roberts 1989). Concerns have been expressed about the ability of tree species to respond to future climatic changes because the predicted rates of change are 15–40 times greater than those observed in past millennia (Peters 1990). Furthermore, land-use patterns have created barriers to plant migration. Agricultural lands, freeways and urban centers present formidable obstacles to tree species whose seed dispersal mechanisms are often limited to short distances (Peters 1990).

Migration of individual species in response to climate change may be further constrained by soil conditions. At the northern treeline and at high elevations, soil conditions may be inferior to those in the species' current habitats. Substantial reductions in boreal forest extent have been predicted as a result of differential shifts in its northern and southern boundaries (Zoltai 1988, Sargent 1988). Similar reductions in area are possible in other forest types if different factors are responsible for the change in growing conditions at opposing borders. For example, increase in disturbance regimes may alter community structure more rapidly than species migration in response to more favorable growing conditions.

Implications for Resource Managers

Increased Uncertainty

Climate change will increase the uncertainty about how forests will be distributed in the future, what their species composition and growth rates will be, and how they will be disturbed through fires and insects. Not all impacts of climate change will be detrimental as increased temperatures may benefit productivity in some areas. Climate change represents both danger and opportunity. The challenge to the resource manager will be to minimize danger and to take advantage of opportunities.

How can dangers and opportunities be identified if there is so much uncertainty about climate predictions and forest responses? We suggest that forest managers concerned about long-term planning horizons (a decade or more) employ scenario analyses of different what-if climate and forest response scenarios to explore the potential implications of climatic change to the resource they are managing. Through such analyses, insight can be gained on several points. The components of the system under management that are most vulnerable to changes in climatic conditions can be identified. Where the success of achieving certain management objectives is highly dependent on an assumed future climate, remedial actions may be taken to decrease this dependency. Species selection, for example, should take into account that climatic conditions may become warmer and drier and that planting a species near the edge of its range, given the chance for reduced moisture, may significantly increase investment risks.

Long-term wood supply analyses should explore the implications of changes in growth rates (increases or decreases) on the projected harvest levels. To our knowledge, not one of the existing operational growth and yield programs and yield tables considers the effect of climatic variations on future yields.

Disturbance regimes are a second important determinant of wood supply. Even small changes in areas annually burned can translate into significant reductions in long-term sustainable harvest levels (van Wagner 1983, Reed and Errico 1985). It is therefore important to continue to monitor disturbance regimes and to reflect changes in fire and pest conditions in the calculations of annual allowable cuts.

Maximizing Productivity or Minimizing Risk: Insurance Strategies

Decisions about tree species selection for planting are currently based on silvicultural criteria, guided by anticipated future demands for the planted species. Under climate change conditions, forest managers will have to take into account the future productivity of the species and the risk of disturbance through pest or fire.

Reductions in rotation length are one mechanism by which risks of disturbance impacts can be reduced. Where wood supply is the primary management objective, repeated short rotations can facilitate the transition to future climatic conditions, provided that technological changes in harvesting and processing technologies further reduce the economic dependence on large piece sizes. Forest ecosystems which are valued for their age and undisturbed state, such as parks, old-growth forests and ecological reserves, are particularly sensitive to the increased disturbance risks.

Trees are most vulnerable to climatic extremes in the early regeneration phase. Clearcut logging maximizes exposure of planted seedlings and increases the temperature amplitude at ground level. The suitability of harvesting techniques which maintain some overstory component should be investigated as one tool to reduce regeneration failure under warmer and drier climatic conditions. The increased disease risk (root rot) often associated with multiple stand entries must be carefully weighed against the potential gains from increased regeneration success.

One possible approach to dealing with future changes is to enhance structural complexity and to maintain genetic diversity in forest systems, with the assumption that some systems will be better able than others to adjust to climatic changes. By monitoring the forest responses and comparing them to the predicted responses, forest managers can gain insights and adaptively manage under the evolving climatic conditions.

Mitigation Options

Climate change may have substantial impacts on the way society perceives the role forest managers can play in affecting the environment. Deforestation and the conversion of forests to agricultural land have historically contributed substantially to the annual CO_2 input into the global atmosphere (Woodwell et al. 1983). Reductions in forest area in the United States ceased several decades ago and forest area has risen slowly since 1950. Deforestation continues, however, at an alarming rate in many other parts of the world. Forest managers should contribute to efforts to slow down global deforestation, in the name of global resource conservation, while they take an active role in increasing terrestrial carbon sinks through the enlightened management of the forests within their control. Harvesting regimes that maximize product utilization and minimize carbon losses from the site, prompt reforestation of harvested areas, extra effort to afforest marginal and disturbed sites within the forest boundary, afforestation of marginal crop and pasture lands, establishment of shelterbelts, and the planting of urban trees can all contribute to removing CO_2 from the atmosphere. Each of these opportunities lies within the grasp of forest managers and citizens.

It has been estimated that the carbon exchange between North America's forest and the atmosphere is at or near steady state: North American forests as a whole represent a small carbon sink (Birdsey 1991, Kurz et al. 1991). Regional exceptions may exist: the conversion of coastal old-growth to second-growth forests on the west coast may represent a small region carbon source (Harmon et al. 1990). Research projects are under way in the U.S. and in Canada to explore the implications of management actions and climatic change scenarios to the future carbon balance between the forest sector and the global atmosphere.

Forest managers should be aware of the fact that they are in control of the only significant carbon sink which can be managed through human activities. Large scale reforestation has already been discussed as a means of sequestering atmospheric carbon to reduce the rate of increase (Marland 1988, Sedjo 1988). Forest managers may therefore become subject to increasing public scrutiny and may be encouraged to alter management objectives towards carbon conservation if society considers climate change impacts to be undesirable. Although forest managers exercise limited control over the carbon uptake and retention in forest ecosystems, concentrations of radiatively active gasses in the atmosphere are only controllable through effective energy policies aimed at reducing fossil fuel carbon emissions. Bioenergy as a substitute for fossil energy sources may play an increasing role in net reductions of fossil carbon emissions into the atmosphere.

Conclusions

The remaining uncertainties about the timing and regional expression of climatic changes are no longer a valid justification for inaction as evidence is increasing that climate change is real. The anticipated responses of North American forests to these changes are sufficiently large to warrant concern and a call for action. What-if analyses of different climatic change and forest response scenarios can be employed to explore the opportunities and dangers ahead. Adaptation and mitigation strategies are available and research efforts should be increased to quantitatively explore their implications.

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Conservation in Temperate and Tropical Rain Forests: The Search for an Ecosystem Approach to Sustainability

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Introduction

Over the past decade there has been an enormous increase in concern worldwide for tropical rain forests. Many people know of the unusual diversity and luxuriance of tropical rain forests and in most of the countries in which they occur local people, organizations and governments are making significant commitments to programs of forest conservation. A similar concern for temperate rain forests is beginning to develop close to home which will add much needed credibility to the voice of North American conservationists around the world. While there are great differences in the nature and magnitude of the forces driving exploitation, there are also fundamental similarities in the approach needed to be successful in temperate and tropical ecosystems.

The socio-economic reality associated with growing populations of rural poor in most developing tropical countries makes it difficult to preserve rain forest parks and protected areas. ''Sustainable development'' initiatives designed to integrate conservation and development, and promote sound forest and natural resource management offer more promising opportunities to gain the support of both governments and local people. Biosphere reserves, for example, provide a sound framework for the conservation of genetic diversity, research and rural development.

In North America, parks and protected areas designed to separate man and nature have been the centerpiece of the conservation movement. As the global human population grows and its economy increasingly degrades the life support capacity of the earth, environmentalists will increasingly have to direct their energies to ecological processes, ecosystem function and the man/nature relationship. The movement will evolve from preserving species, habitats and scenic wilderness to maintaining life support systems. Ecosystems will be defined as ''man/nature'' ecosystems or ''social'' ecosystems to describe ''whole'' units of research, conservation and regional planning. It is no longer desirable to separate man and nature for either theoretical or practical purposes. Marston Bates (1960) made this point clearly: ''Ecologists leaving man out of nature is as unfair as economists leaving nature out of economics. The economy of nature and ecology of man are inseparable . . .''

I predict that the trend towards a more holistic ecosystem approach will move the conservation agendas of the developing tropics and the developed temperate countries closer together. The long-awaited ''paradigm shift'' towards global environmental security will utilize universal principles but respond to the variety of local customs and circumstances. And a great deal will be learned from the experience in the developing tropics.

Rain forest conservation and management is a microcosm of the bigger picture. In this paper, I will explore the status and distribution of temperate and tropical rain forests and outline a unifying conservation strategy I call ''ecosystem economics''—an ecosystem approach to sustainability.

Tropical Rain Forests

Scientists estimate that there are some 2.2 billion acres (900 million ha) of tropical rain forest worldwide, an area of about 6 percent of the earth's terrestrial surface, providing habitat for at least 60 percent of all the species of plants and animals (Conservation International 1990). Within the tropical rain forests of the world, there are areas of particular importance for biological conservation now commonly called ''hot spots'' (Myers 1988). A combination of exceptional species diversity, high rates of endemism and rapid rates of deforestation define these limited areas where some 13 percent of all flowering plant species occur and as much as one-half are threatened with extinction in the next decade on just 0.02 percent of the earth's land surface (Conservation International 1990). Of the total area of tropical rain forest, approximately 62 percent has been logged or converted to non-forest use (Conservation International 1990).

The largest single area of tropical rain forest worldwide, and the home of the greatest overall species diversity, is in the Amazon basin. Most of the Amazon Basin is in Brazil. While logging and slash burn agriculture are converting huge amounts of forest yearly, the forest is vast and recent estimates are that just 9 percent of the Brazilian Amazon has been deforested. In parts of the northern and western Amazon, Zaire and the island of New Guinea, vast tropical rain forest ''wilderness areas'' remain (Conservation International 1990).

Temperate Rain Forests

With all the interest in tropical rain forests, and perhaps a penchant for preaching abroad the things we have failed to do at home, until recently, we all but forgot that rain forests occur in temperate realms as well.

Based on preliminary data gathered for Conservation International, and a new organization created by Conservation International specifically for temperate rain forest conservation called Ecotrust, the original distribution of temperate rain forests covered an estimated 76.1 million acres (30.8 million ha) worldwide (Weigand 1990, Moore 1991). This is an area roughly the size of Wisconsin, less than 4 percent of the area of tropical rain forest. We have developed a preliminary working definition of temperate rain forest as those areas of closed canopy forest with 80 inches (2,000 mm) or more of annual rainfall, absence of summer drought and generally moderate temperature regimes (Weigand 1990). Preliminary estimates have been limited to coastal regions, where most temperate rain forest occur (Figure 1).

Historic areas of temperate rain forest in the Old World appear to have been virtually extirpated. The west coasts of Ireland and Scotland, the southeast coast of Iceland, the southwest coast of Norway, and relatively small areas on the Black Sea coasts of Soviet Georgia and Turkey no longer have significant stands of original rain forest vegetation. Overall, our estimates are that 42.5 million acres (17.2 million

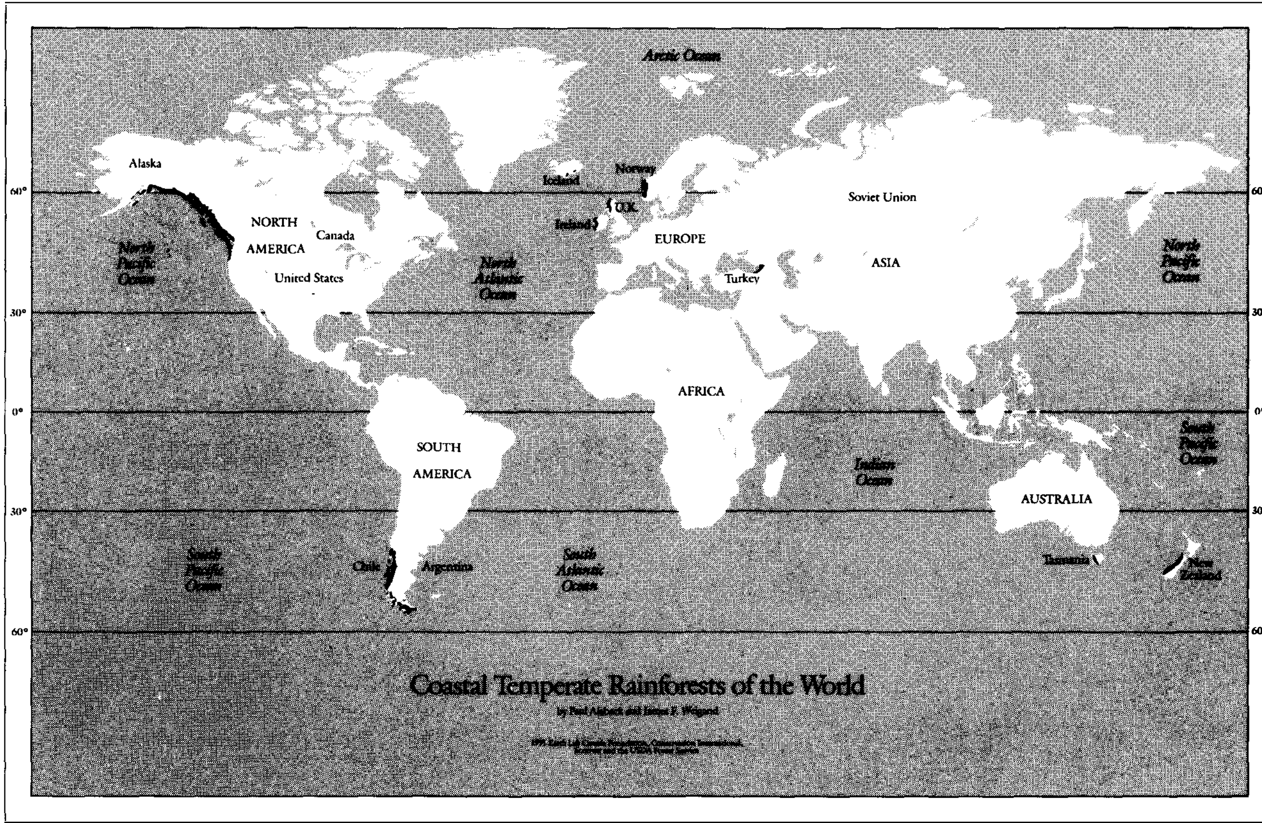

Figure 1. Coastal temperate rain forests of the world.

ha) or 56 percent of the total have been logged or converted to non-forest use (Weigand 1990).

The largest area of temperate rain forest in the world is on the west coast of North America from central Oregon to the Alaskan Peninsula. This is a predominately coniferous forest originally covering some 35.4 million acres (14.3 million ha) (Weigand 1990). The temperate rain forests of coastal Chile, which include both coniferous and broadleaf forests, total some 18.8 million acres (7.6 million ha) but are fragmented by rapid rates of logging (Weigand 1990). Relatively large protection areas have been established in temperate rain forests of western Tasmania, the west coast of the South Island of New Zealand, and the Tongass National Forest in southeast Alaska. Nowhere are there vast intact temperate rain forest ecosystems nearly the size of the remaining tropical rain forest wilderness areas.

The stability of climate, abundant moisture and low frequency of catastrophic disturbance also make temperate rain forests the most productive of all terrestrial ecosystems. The forests of the southern range of the Pacific northwest accumulate as much as 500–2,000 metric tons of organic matter per hectare, standing biomass two to three times that of even the most productive tropical rain forests (Weigand 1990). Because of their high levels of productivity, temperate rain forests have been subject to high rates of logging and have been an important base to local and regional economies wherever they occur (Weigand 1990).

On a global overview basis, it appears that temperate rain forest ecosystems are rarer, more productive and at least as threatened as tropical rain forest ecosystems.

The Ecosystem Lens in the Search for Global Rain Forest Conservation Priorities

The shifting emphasis from species and biodiversity to broader ecosystems and ecological function will involve the conservation of representative ecosystems of all kinds worldwide. It is vitally necessary, but not sufficient, to maintain the full array of biological diversity in parks and protected areas. It is also important, indeed I would argue more important, to study and sustain the full array of ecosystem types and ecological processes: marine and terrestrial, temperate, arctic and antarctic, as well as tropical. This will involve decisions and priorities, not in terms of final objectives, but in terms of where and how to spend limited resources first. One approach would be to combine the conservation of rain forest ''hotspots'' with representative rain forest ecosystems, thereby maximizing biodiversity objectives, as well as beginning the process of global ecosystem conservation.

Looking, for example, at temperate rain forest ecosystems on a global basis, CI has been drawn to the largest remaining forested area of the Pacific northwest. The linkage of terrestrial and marine ecosystems of this coastal forest type is perhaps its most distinctive feature. Moisture from the sea, falling on adjacent coastal mountains, then washes vital organic nutrients through a complex network of forested streams back to the marine environment. Anadromous fish and the marbled murrelet perhaps best symbolize the tight interdependence between terrestrial and marine, as well as coastal and estuarine components of this ecosystem. Using these basic ecological characteristics, whole, unlogged coastal watersheds have become vital base line units of measurement and an important focus of the search for North American temperate rain forest priorities. Coastal watersheds, and the quality of water flowing from them, are integrators of ecosystem health. The conservation of genetic diversity, large populations of large animal species, and the principle ecological processes which sustain these systems are most effectively done at the watershed level (Lertzman and Kremsater in preparation).

In the lower 48 U.S. states, even extending the search beyond our own technical definition of rain forest down the coast to include transitional coastal forest in southern Oregon and the fog belt coast redwoods, we have been unable to find a single unlogged whole coastal watershed of any significant size, even in existing parks and protected areas, with the exception of the 30,000 acre (12,100 ha) Cummins Creek area in the Siuslaw National Forest of central Oregon (Weigand 1990).

In adjacent British Columbia, over the course of the past year we have looked at the provincial Ministry of Environment's watershed coding system computer data base, and identified 354 coastal temperate forest watersheds over 12,500 acres (5,000 ha) in size and assessed their status in terms of logging and development protected and unprotected status (Moore 1991). Two-thirds of all these have been logged or developed to a substantial degree and just 20 percent remain "pristine." Just 9 of the 354 whole watersheds, or 2.5 percent are in protected status. Only 1 of 25 large watersheds (over 250,000 acres:100,000 ha) remains significantly unlogged, the Kitlope River system. Virtually all the remaining unlogged watersheds in unprotected status in British Columbia are tenured to industrial forest products companies in commercial tree farm licenses or timber supply areas and subject to logging in the near future. On Vancouver Island, we looked at all coastal watersheds over 12,500 acres (5,000 ha) and found only 5 of 90 remaining pristine, of which just 1 is in protected status.

Based on this "coarse ecosystem filter" assessment of large, unlogged coastal temperate rain forest watersheds, we are proceeding with more careful satellite image analysis and field work with multi-disciplinary teams of Canadian scientists to describe priority whole ecosystems which include the unlogged watersheds, along with appropriate adjacent estuarine, coastal and marine components. In Alaska, as well as the lower 48 U.S. states, we are using similar methodology, in order to be able to compare ecosystem priorities across the entire biome, regardless of national political boundaries.

This is a fundamentally different approach than a country by country, endangered species, or "old-growth" strategy to identify conservation priorities, and leads to different results. Just two years ago, a map was published in British Columbia identifying provincial conservation priorities to increase the overall percentage of the province's protected area system from 5 percent to over 13 percent (Valhalla Society 1988). This is a very important objective and a worthy effort. But, neither the map nor the conservation or scientific communities at the time recognized the Kitlope River/Gardner Canal region where by far the largest unlogged adjacent coastal temperate rain forest watersheds occur, an area I believe should be among the top conservation priorities worldwide.

The interest in "old-growth" or ancient forest is important and comes none too early in Oregon and Washington where only 6–9 percent of the original forest in the Douglas-fir region remains in mostly tiny, isolated fragments (Weigand 1990). But age class should, in my view, be a subset of a larger forest ecosystem perspective, whether for research, conservation or commercial forest management. In the cases of British Columbia and Alaska, the circumstances of Oregon and Washington should not be directly translated to a concern primarily for "old-growth". Here we should capitalize on the relatively unusual world-wide opportunities to develop long term programs of baseline research, conservation and truly sustainable forest ecosystem management in the few remaining large coastal watersheds.

Ecosystem Economics: The Ecosystem Approach to Sustainability

Using an ecosystem lens in the search for global priority representative ecosystems is just the beginning. Long-term programs of research, conservation and adaptive management need to be designed and implemented. For Pacific northwestern coastal temperate rain forests we are using watersheds and local human communities as the principal organizing unit for defining "social-ecosystems." Perhaps an example will best illustrate the particular approach.

Since there are no remaining large, unlogged coastal temperate rain forest watersheds in the continental U.S., we are faced with the need to pursue ecosystem rehabilitation to rebuild a semblance of a natural system in the southern reach of the biome. Together with The Nature Conservancy, we have chosen the Willapa Bay watershed ecosystem, in southern Washington (Figure 2). The watershed includes some 680,000 acres (275,200 ha) the second largest estuary on the west coast after San Francisco Bay, 30 miles (48 km) of ocean beach, and some of the most productive timberland in the world. All but a few thousand acres—roughly 0.05 percent of the total terrestrial base—has been logged two to three times over the past 120–130 years and most of it is owned by large industrial forest companies.

The Willapa Bay ecosystem economy is entirely natural resource based. The 18,000 people who live there depend on fishing, oystering, farming, forestry and tourism. The ecosystem produces an annual total "ecosystem product" of roughly $120 million and has been described as the most productive ecosystem in the continental U.S. (Tice and Forrest 1990). And yet, the ecosystem's principal county economy is among the poorest 10 percent of the state in terms of per capita income and unemployment. A major challenge to local communities is attracting 16–24-year-olds who forsake the scarcity of economic choices for larger cities in the region.

No ecological baseline study exists for this social ecosystem, and a growing list of potential threats are arousing strong local concern: the geometrically-increasing rate of spread of the exotic cordgrass *Spartina* and epidemic populations of the native ghost shrimp in the rich oyster beds of the tidelands, effluent from expanding real estate development, the chemical composition of the nearby coastal plumes of the Columbia and Chehalis Rivers, and water quality from upstream land use.

The long-term goal of the Willapa Bay program will be restore to and maintain the diversity and productivity of the system as the base for healthy and sustainable economic development. From this a number of basic principles and short-term objectives emerge.

Principles

1. The watershed ecosystem is the natural unit of planning. A 1,000-year time frame (senescence of dominant tree species) is a useful reference.
2. The principal tool is land and water management (or absence thereof).
3. We are largely ignorant about the long-term consequences of particular man-

agement practices and therefore must continually adapt them to new knowledge, technology and understanding, and build learning explicitly into the decision-making process.

4. In order to reduce our ignorance and enhance our chance of success, we need an ongoing program of ecosystem level research and monitoring.

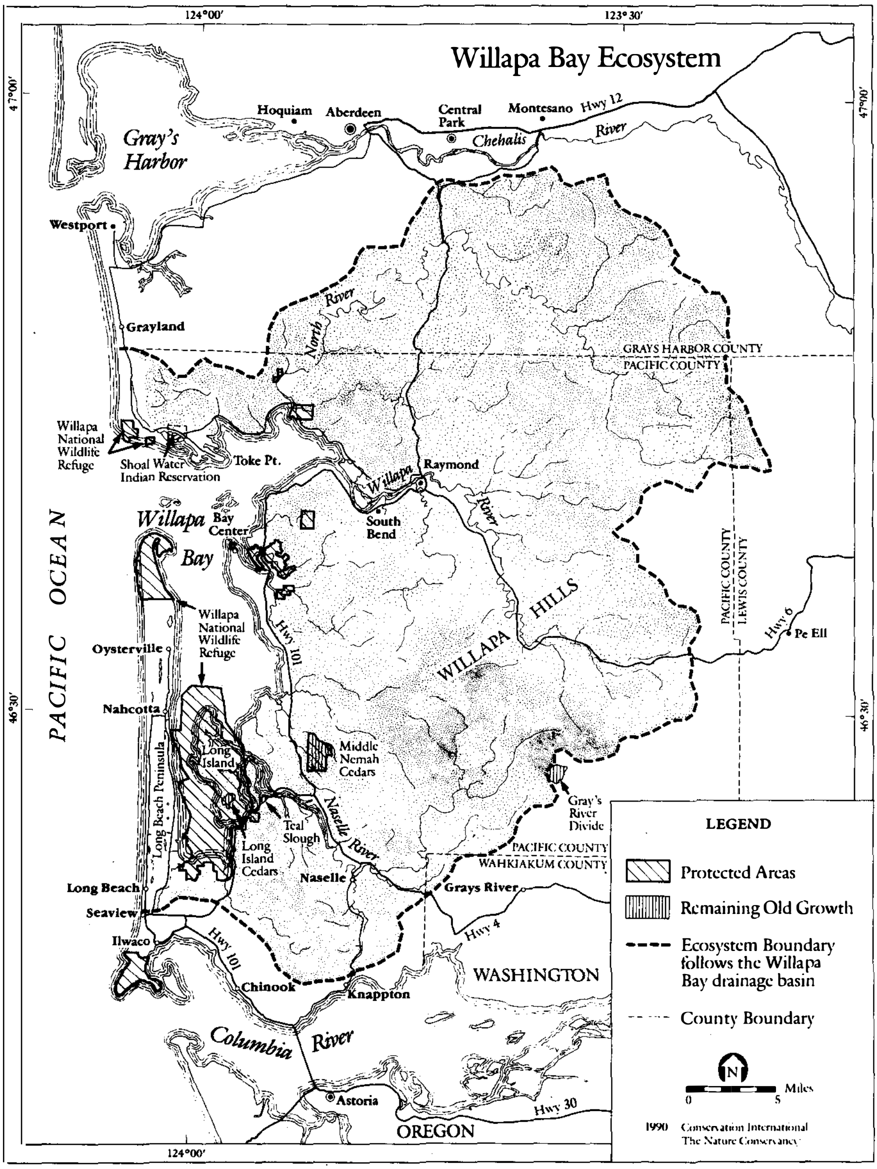

Figure 2. Willapa Bay ecosystem.

Short-term Objectives

1. Identify and listen to local leadership: major landowners, farmers, fishermen, foresters, business owners and political leaders.
2. Help local leadership to develop the organizational capacity to research and monitor the health of the ecosystem and the local economy, and provide reliable information for regenerative mariculture, forestry and farming.
3. Help build a local, non-governmental ecosystem conservation and development organization to promote community education, extension and fund raising.
4. Help create local, state, national and international governmental policies and regulations that would promote ecosystem restoration and sustainable development.
5. Foster economic development projects that are profitable and competitive, employ local people, add value to local natural resources, and help restore and maintain the ecosystem.

Using local community based economic development as a tool for restoration and maintenance in Willapa Bay will be a particularly significant and difficult challenge. Integrating economics and ecology strikes me as the essential problem worldwide.

Creating a profitable, ecologically and socially responsible, as well as competitive business will be no more simple than understanding and monitoring ecosystem health. But, a window of opportunity may be developing through "socially responsible" investing to test the idea that sustainable development may have access to cheaper capital than non-sustainable development. "Socially responsible" investing is a very fast growing segment of the investment community and now accounts for over 850,000 investors who are using social and environmental screens to help them choose where they put their money. Socially and environmentally responsible businesses which could generate real rates of return of 3–4 percent while staying at least even with inflation would be competitive with traditionally conservative investments in bonds and government securities. Once tested, who would prefer to invest in governmental security over environment security?

My own estimates are that second-growth timberlands in the Willapa ecosystem could be acquired and managed according to "new forestry" principles, and generate competitive returns while dedicating 15–20 percent of the land base (coastlines, wetlands, riparian zones and wildlife corridors) to "old-growth" age classes. Real rates of return of 3–4 percent are consistent with annual biological growth rates, some of which can be enhanced by advancing natural succession through thinning and reasonably well-tested silvicultural practices. "Green-marketing" from chemical-free ecosystem and sustainable development zones might further enhance returns. These would probably never approximate most Wall Street investment expectations, but a high degree of security would attract lower risk/lower return investors for at least part of their portfolios. Conceivably, this could be the case as well for very large institutional investors managing pension funds. Timberlands, of course, are only one of a virtually unlimited number of natural resource or nature based tourism opportunities for socially and environmentally responsible investors in Willapa Bay.

Willapa Bay is but a microcosm of the larger global predicament. If it is not possible for a relatively stable and modest population of 18,000 people to enhance or even maintain their quality of life in one of the richest, most diverse and productive ecosystems on earth, in one of the most stable and strongest economies and political systems anywhere, what are the prospects for mankind generally? Other rain forest ecosystem programs will of course be quite different than Willapa Bay, where the history of exploitation suggests that restoration must be a key objective, and community based economic development might itself be a central force for restoration. Other programs may emphasize ecosystem level research and monitoring, subsistence use by indigenous peoples, wilderness preservation or biosphere reserves. But the search for underlying principles based on a holistic ecosystem perspective will be similar: an assessment of global ecosystem priorities, the characterization and understanding of man/nature ecosystems, empowerment of local people with access to information, capital, technology and political influence, and monitoring the health of the socio-economic ecosystem over time. These themes seem relatively straight forward, but bringing them all together even in small, well-defined ecosystems close to home is a very great challenge. None of these ideas are by themselves new, and there is successful experience in each of them scattered around the world. Bringing them together in priority ecosystems, putting them into practice on a significant scale over time, then extrapolating the results across the political and ecological landscape will be difficult. But I see no alternative but to try.

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Trends in Timber Demands and Supplies: Implications for Resource Management in the 21st Century

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Introduction

The 1989 RPA Assessment (USDA Forest Service 1989d) and 1990 RPA Program (USDA Forest Service 1990) documents are a significant collection of information about demands and supplies for renewable resources in the United States. The Assessment is comprised of a summary and 12 supporting documents, including supporting documents for each major resource category. The Program draws on the Assessment findings to develop a strategic plan for the U.S. Forest Service. Key findings in the Assessment and Program form the basis for this discussion. The discussion is organized to first present projections of demands and supplies for all renewable resources, including timber; second, potential sources of structural change in the outlook and finally the implications this projected future may have for resource management. The combined future demands and supplies for the various renewable resources largely determine management implications for the timber resource in the 21st century.

Renewable Resource Demands

A growing and increasingly more affluent U.S. population will result in increased consumption of all renewable resources in the future. The U.S. economy has been shocked periodically over the past 60 years with the Great Depression, world war, and double-digit inflation. A current problem is the Federal budget deficit. The economy has always managed to come back, however, and we project that this resiliency will continue in the future. We project that the U.S. gross national product will quadruple in real terms in the next 50 years, reaching some $16 trillion in 2040 (USDA Forest Service 1989c). A main driver of the economy will continue to be a growing population. We project the U.S. population to increase by more than one-third by 2040 to 333 million people. Much of the increase will be due to immigration from Pacific Rim and Hispanic countries. The U.S. population is expected to be more affluent, with per-capita disposable income more than doubling to some $28,000 in 2040. Given this expected increase in economic activity and population, there can be little doubt that demands for timber products and other renewable resources will increase in the United States in the future. These timber demands will draw on roundwood supplies in all U.S. regions and Canada (Haynes 1991).

A growing, affluent population will also lead to increased demands for many forms of outdoor recreation, high-quality water, forage, minerals, and other nontimber outputs of the nation's forest and rangelands and associated waters (Cordell, et al.

1990, Flather and Hoekstra 1989, Guldin 1989, Joyce 1989, USDA Forest Service 1989b). Some of these demands are increasing faster than demands for timber, for example, as in the case of hiking and wildlife observation.

Trends in Renewable Resource Supplies

Timber

For the country as a whole, harvest (removals) on timberland in the United States increased 30 percent between 1952 and 1986 to 16.5 billion cubic feet (467 million cum) (Waddell, et. al. 1989). The increase was somewhat higher for softwoods than for hardwoods. While harvest increased nearly 40 percent, growing stock inventory on timberland also increased nearly 40 percent, growing stock inventory on timberland also increased nearly 25 percent to 756 billion cubic feet (21.4 billion cum). The increase for softwood inventory was 5 percent to 450 billion cubic feet (12.7 billion cum) and for hardwood inventory, 69 percent to 305 million cubic feet (8.6 billion cum). Inventory and harvest both increased despite a decline in timberland acreage of 5 percent between 1952 and 1986 to 483.3 million acres (195.6 million hectares) (USDA Forest Service 1989). These trends, by themselves, speak well for the productivity of forestry resources in the United States as a whole.

The U.S. timber supply situation, however, varies considerably among the regions and ownership classes. In both the North and South, private ownerships account for much of the timberland area, timber inventories and harvest. For example, these ownerships account for 80 percent of the timberland area in the North and 90 percent in the South. Within the private land category, forest industry ownerships are more important sources of timber supply in the South than in the North. Forest industry lands are generally managed with timber as the primary objective while other private lands are typically managed for a variety of objectives. In both the North and the South, hardwood and softwood timber inventories have increased over the period, 1952–1986, with the total being up 72 percent. Especially on forest industry ownerships in the South, forest management has been relatively more intensive than on other ownerships in the North and South. This has resulted in a continuing increase in the acreage of pine plantations in the South from 1.8 million acres (747,000 ha) in 1952 to over 20 million acres (8.5 million ha) in the late 1980s.

In the West, public land, and primarily Federal lands, are a relatively more important source of timber supply than in the East, but private lands still account for over one-half of the total harvest. Unlike the relatively optimistic picture for future timber supplies in the East, there are key trends and issues that affect the outlook for timber supplies from both private and public lands in the West, especially in the state of Washington, Oregon and California. On private lands, old-growth inventories have been largely harvested and timber supplies from these lands will likely decline, at least in the next several decades, as second growth inventory accumulates. Logs from these lands will also be smaller diameter than in the past as second growth timber accounts for an ever increasing proportion of the harvest. On public, and especially federal timberland, conflicts between timber harvesting and other management objectives, such as protection of habitat for threatened and endangered species, are sometimes leading to reduced timber harvest.

Nontimber Resources

Supplies of many nontimber resources come largely from the same forested lands that are valued for timber production. Effective integration of the management of these resources increasingly constrains the supply of any one resource taken in isolation, especially on lands managed under a multiple-use mandate. Increased designation of public lands for amenity uses will tend to shift demands for commodity uses to private and remaining public lands. As use of private lands intensifies, interactions among resources on these lands are expected to be more severe, too. How these interactions are managed and the environmental values are protected will largely determine how much state and local governments decide to regulate the management of these lands.

Projections of Renewable Resource Use

Timber

For the United States as a whole, timber harvest is projected to increase to 27.2 billion cubic feet (770 million cum) in 2040 compared with 17.8 billion cubic feet (504 million cum) in 1986. The percentage increase is higher for hardwoods—78— than for softwoods—39. The larger percentage increase in hardwoods reflects the assumptions of continued growth in the use of hardwoods for pulping and in oriented strand board and waferboard. Most of the projected increase in total harvest is on private lands (92 percent), and in the East (87 percent).

Stumpage prices are a good indicator of relative supply and demand balances. Stumpage prices are projected to increase rapidly through 2010 and then level off. For example, softwood stumpage prices on the Pacific Coast increase at an annual rate of 2.6 percent between 1986 and 2010 compared with 1.8 percent between 1952 and 1986. Between 2010 and 2040, prices are projected to increase only 0.5 percent. By 2040, prices decline slightly, but by that time, they are more than double prices in 1986.

As these softwood sawtimber stumpage prices indicate, the United States will be in an unprecedented situation for a shortage of large-diameter softwood sawtimber through 2010. Since its inception, the United States has had a reserve of softwood sawtimber to draw upon. First the Northeast, then the South, the Lake States, the U.S. West Coast, and then Interior British Columbia met the country's needs for construction materials. There is no large reserve of virgin softwood sawtimber left to draw upon and this accounts for the rapid run-up in sawtimber prices through 2010.

This short-term situation will create opportunities for increased hardwood utilization in the East and enhance adoption of wood-saving technologies. It may also create opportunities for Canada, our primary source of imports of softwood lumber, newsprint and wood pulp. After 2010, as the pine plantations in the South begin to reach maturity, sawtimber prices are projected to level off as supply increases.

Projections of international trade in timber products, in the RPA Assessment, are based on judgments and reflect expectations about developments in the domestic U.S. market, Canadian and other sources of wood supply to world markets, and demand prospects in Japan, Europe, and other markets. When Canada and the United States are considered together, North America is self-sufficient, or a net exporter of most products except imports of hardwood panels (United Nations 1990). These panels now originate mainly in Indonesia. Log export restrictions in Southeast Asian countries that were sources of tropical hardwood log exports have shifted log processing back to the countries of origin.

Exports from the United States are projected to represent a relatively small proportion of U.S. output of most timber products—less than 10 percent in most cases. These judgments reflect assumptions that Japan and Europe will continue to be mature markets and that Chile, New Zealand and Brazil will become significant sources of supplies to world markets.

In the absence of a national overview of Canadian demand/supply prospects, there has developed, in Canada, two lines of thought on future harvest levels. One is that harvest levels are near a maximum and that timber supplies can be increased only though more intensive management of the resource. A second line of thought is that existing management plans have made conservative estimates of how much of the timber resource will be economically available in the future. As price rises in the United States, more timber will become economically available. The RPA Assessment projection lies more closely with the first line of thought. It assumes that U.S. imports from Canada will not grow significantly and will remain within a range of 10–12 billion board feet (23.6–28.3 million cum).

Nontimber Resources

Demands for other uses of the forest, such as water, recreation, wildlife and fish, are also projected to increase in the future. One way to meet growing demands for nontimber production or to remix the multiple-use balance among resources. While these changes affect the timber supply/demand outlook in various ways, changes to date have occurred primarily at the margin. Given time, the North American timber economy has been able to adjust to regional shifts in timber supplies by increasing output in other regions, developing wood-based substitutes for products formerly coming from sawtimber and applying technologies that economize on the processing and utilization of wood.

Within the total market's ability to adjust to various pressures, individual regions and/or individual landowners can be materially affected by the mix between timber and nontimber objectives. For example, conflicts over the use of national forests are characteristic of the issues associated with:

- preservation of old growth in the Pacific Northwest;
- set-asides of habitat for threatened and endangered species;
- below-cost timber programs; and
- harvesting in existing roadless areas.

In the RPA Assessment projection, harvest levels on national forests are assumed to reach the sum of harvests for the final forest plans, or the preferred alternatives where the plans were not yet final, by 2000. After 2000, harvest levels are assumed to follow forest plans and reach 2.4 billion cubic feet (67.9 million cum) in 2040 compared with 2 billion cubic feet (56.6 million cum) in recent years. If harvest adjustments are made for the four issues listed above, harvest on national forests could decline 40 percent as compared with the Assessment projection (USDA Forest Service no date).

In general, this sort of reduction in harvest on national forests would simply accentuate trends already reflected in the base-line projection. Softwood stumpage prices rise faster and plateau higher, software lumber prices would increase another 10 = 15 percent, and imports of softwood lumber from Canada would increase by about 20 percent. As measured at the national level, the effects of the decline in national forest harvest are mitigated somewhat by responses from other regions and private harvests. At the local level, however, effects such as reduced employment can be devastating to individuals and communities, at least in the short term. The cumulative effects of these differing timber supply situations among regions and ownerships will tend to lead to increased harvest on private lands with associated interregional shifts in the roundwood processing industries from the West toward the East.

Potential Sources of Structural Change in the Outlook

The projections of timber demand and supply are based on analyses and development of models supported by long data series. The RPA Assessment timber projections also rest upon several explicit assumptions about timber supplies and their interactions with end product demands. The general outlook is not likely to change significantly unless there are pronounced structural shifts in relationships that determine demands and supplies.

There are, however, four potential sources of structural change that could materially affect the future timber demand/supply situation:

- increased recycling of paper and paperboard;
- reduced investments in forestry on private lands;
- global climate change impacts on forest growth; and
- increased international trade in timber products.

Of these sources of structural change, increased recycling and reduced investments in forestry on private lands are believed to have the most potential for being realized and affecting the outlook to 2040 in significant ways. Global change and increased trade could affect the long-term outlook, but given current knowledge, it is believed that they would change the outlook rather slowly and even then, the direction of change in timber supplies and demands is unknown. Thus, the first two sources of structural change are being studied rather intensively and the last two are being monitored for implications to the timber demand/supply outlook.

Increased Recycling of Paper and Paperboard

The RPA Assessment projection assumes that recycling of paper and paperboard will increase from current levels of 25 percent to 31 percent in 2040. Since the Assessment projections were done, the potential for higher levels of recycling has increased along with the recognition that many parts of the country have a shortage of land-fill space. For example, the American Paper Institute has announced as a goal a recovery rate of 40 percent of paper and paperboard consumption by 1995—just four years away.

If this 40 percent goal is achieved and maintained through 2040, there would be major impacts on both the fiber-based and solid wood products industries. For example, a large portion of the plantation acreage in the South has pulpwood as the intended product. If increased recycling reduces the demand for pulpwood, these plantations may be allowed to grow into sawtimber. That increase in sawtimber supply would lead in turn to lower softwood sawtimber prices than shown in the RPA Assessment projection (Figure 1).

Recent announcements of industry capacity expansion show that major investments are being planned to provide facilities to increase use of recycled material. Recycling is being monitored closely by Forest Service analysts.

Reduced Investments in Forestry on Private Lands

Tree planting data show that major investments in forestry have taken place over a long period in the United States (Figure 2). Most of this planting has been done in the South. This sustained level of investment forms the basis in the RPA Assessment for assuming similar plantation establishment will continue.

During the decade of the 1980s, there has been major restructuring of corporate finances in the forest industries. With current knowledge, the effects of these changes on commitments to forest management are unknown. The potential effects of a decline in investment are so important to the U.S. timber supply situation that the timber management assumptions underlying the RPA projection are being reviewed. If investments are expected to decline, the currently projected short-term shortage of sawtimber could turn into a long-term problem.

Global Climate Change Impacts on Forest Growth

The extent of potential impacts of global climate change on forest growth are currently speculative. Increased growth may result if warming is accompanied by increased moisture. Decreased growth may result if warming is not accompanied by increased moisture. Type conversions may also occur. For example, red alder may

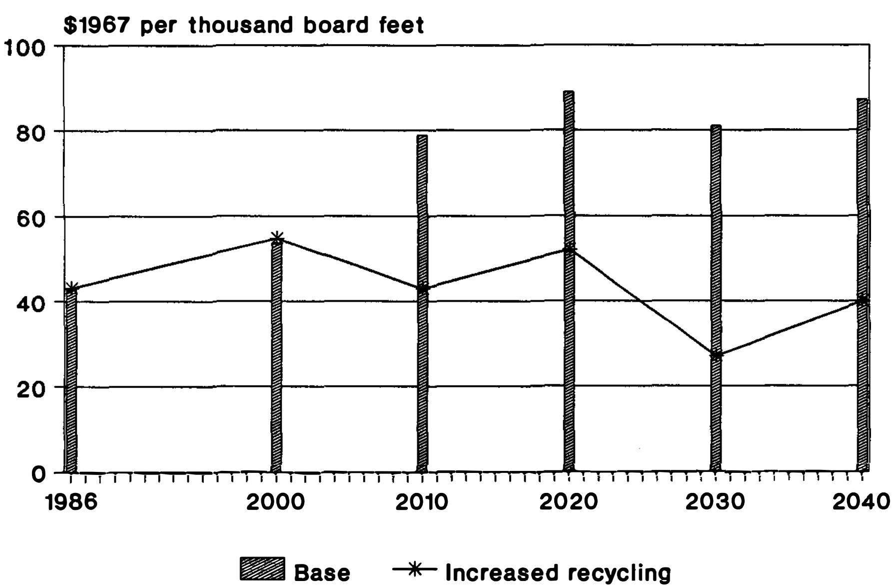

Figure 1. Softwood sawtimber prices in the South—1989 RPA Assessment projection and increased recycling projection.

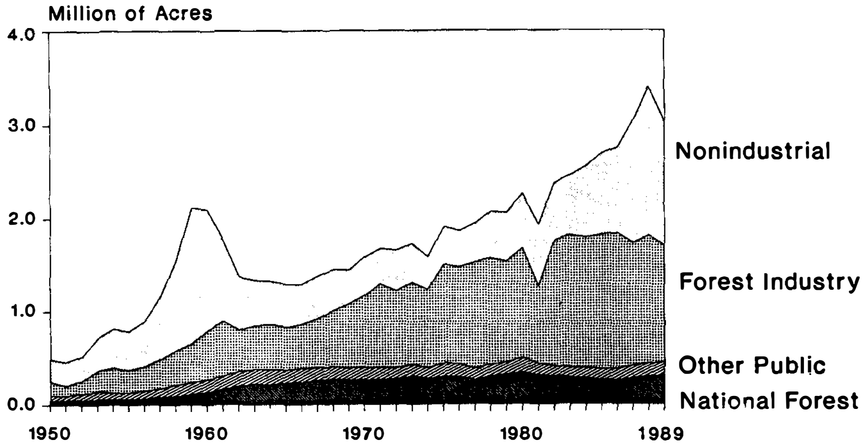

Figure 2. Tree planting in the United States.

replace Douglas-fir in parts of its range. There is a growing consensus that any global change will occur slowly (Joyce et. al. 1990). The effects of any growth decline would tend to build through time. For example, if the growth decline is on the order of 10 percent, softwood lumber prices would be another 4 percent higher in 2000 and another 12 percent higher in 2040 as compared with the RPA Assessment projection. Similarly, the effects of growth increases would build through time.

Increased International Trade in Timber Products

The growing economies of the Pacific Rim countries and the sweeping political changes in Europe may offer greatly expanded trade opportunities for U.S. industry. Conversely, fast–growing plantations in Brazil and other emerging sources of supplies may lead to increased U.S. imports, especially for fiber-based products, and increased competition in world markets. The RPA Assessment projections of trade are based on the historical perspective of the past several decades.

Structural changes in foreign markets could, in turn, lead to structural changes in U.S. trade patterns. If an increased share of domestic supplies were exported, for example, prices for sawtimber and end products would rise in the U.S. domestic market. For example, softwood lumber prices would be another four percent higher in 2040 if exports doubled. If U.S. imports of forest products were to double, there would be reverse effects on prices. Domestic prices would decline and timber inventories would build as compared with the RPA Assessment projection. Since trade patterns generally change slowly, international trade can be monitored and fed back into new projections. For example, considerable market development work would be necessary to expand exports and years are necessary to increase areas of plantations.

Implications for Resource Management in the 21st Century

In the absence of structural change, the future timber outlook in the short-term indicates increasing competition between timber and other renewable resource uses and values from forest land. Analysis of data from national forest plans indicates that resource interactions do become limiting on production of multiple outputs from a fixed acreage of forest land even if considerable costs are incurred to mitigate negative interactions (Hof and Baltic 1988). To date, this competition has been reflected mainly in debates over management of public lands and implementation of local regulation of the management of private lands in some parts of the country. Decreased timber harvest on public lands and increased incidence of local regulation favors the outlook for some renewable resources such as high-quality water, wetlands, some species of fish and wildlife, and some forms of outdoor recreation.

Resolutions of management conflicts that shift the multiple-use balance toward these other resources create both opportunities and challenges for land managers. Our nation's forestlands will increasingly be expected to provide a mix of products and access necessary to meet the needs of a growing population. Increased recycling, increased imports and, under the right conditions, global change could relieve the pressures on forestlands. On the other hand, global change, reduced investments in forestry on private lands and increased exports could exacerbate the costs of trade-offs among these resource conflicts.

The U.S. forest resource has proven productive and resilient in the past and it will undoubtedly continue to be so in the future. Management of the timber resource within the context of increasing demands for all renewable resources, however, will prove to be a resource management challenge for the rest of this century and throughout the next one.

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Use of Biodiversity Indicators for Analyzing and Managing Forest Landscapes

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Introduction

Changes in people's expectations and values are causing dramatic changes in the management of National Forests. New Emphasis is being placed on ecological principles and the need to sustain a high quality environment while also producing needed natural resources (Gillis 1990). The emerging scientific disciplines of conservation biology (Soule and Wilcox 1980, Schonewald-Cox et al. 1983, Soule 1986), landscape ecology (Forman and Godron 1986) and biodiversity conservation (Wilson and Peter 1988) provide useful concepts and tools to augment traditional approaches to land management.

Klamath National Forest (KNF) in northern California is addressing biodiversity as one of the core issues in the development of a new Land and Resource Management Plan. Drawing on the expertise of a team of researchers, land managers, ecologists and biologists (including the authors), KNF is developing a process for evaluating effects of management alternatives on forest biodiversity at landscape, National Forest and bioregional scales.

In this paper, we present: (1) an overview of biodiversity of KNF and Klamath Physiographic Province; (2) examples of how past land management trends have affected biodiversity in the U.S. Pacific Northwest; (3) a generalized approach to planning for biodiversity in National Forest Land Management Plans; and (4) a set of indicators of biodiversity being used on KNF to evaluate the effects of management alternatives on biodiversity, and some preliminary data reflecting current conditions on KNF relating to the indicators.

Biodiversity of Pacific Northwest U.S. and Klamath National Forest

The first step in understanding effects of management activities and considering the role of biodiversity on a particular national forest is to interpret the broad geographic context in which that forest resides (Swanson et al. 1988, *see also* Barnes 1989). KNF occurs in the Klamath Physiographic Province which is part of a broader biotic region of Pacific Northwest U.S. (Figure 1).

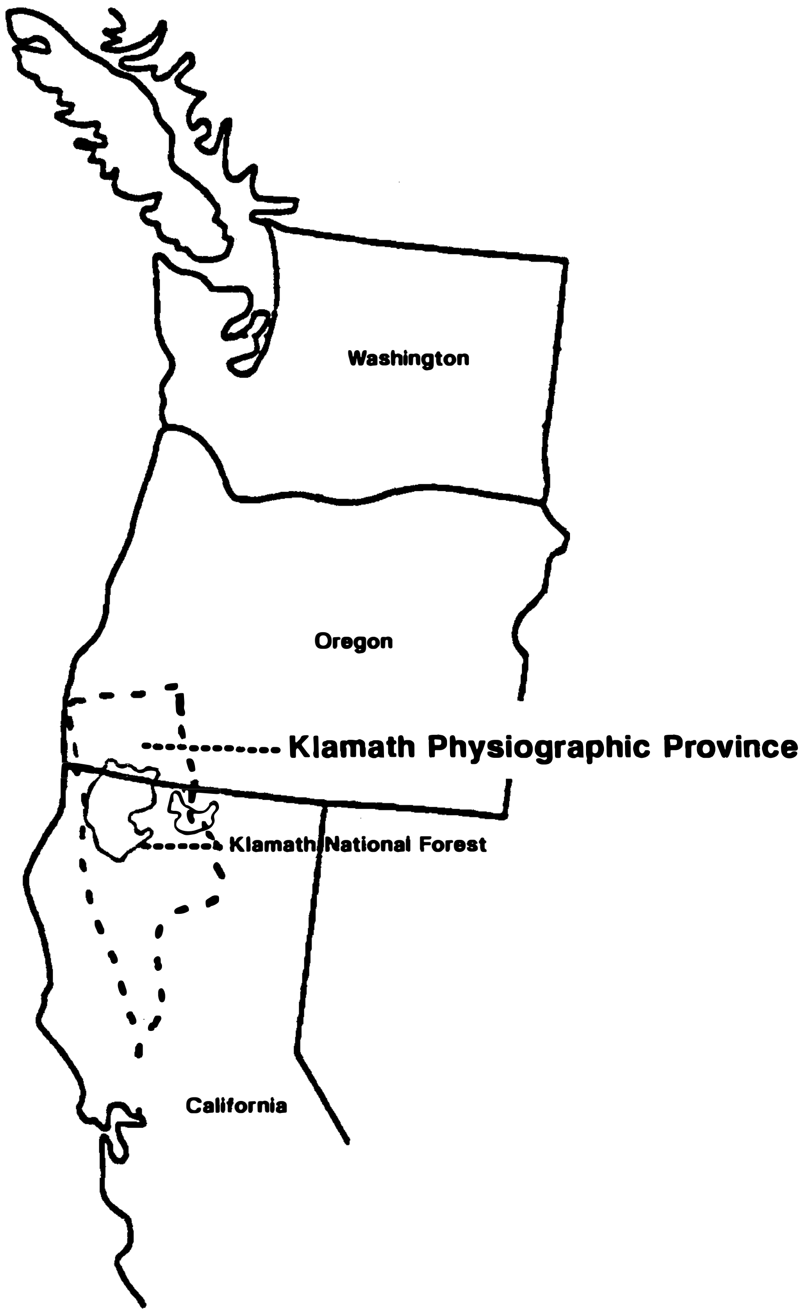

Figure 1. U.S. Pacific Northwest and Klamath Physiographic Province.

Much of the Pacific Northwest west of the Cascade Mountain Range consists of moist Pacific Douglas-fir (*Pseudotsuga menzeisii*) plant communities. Landscapes range from a fairly homogeneous character with large stand sizes to a complex disturbance regime and landscape pattern. Significant attributes of these seasonally high-rainfall forests are the structural diversity and the large biomass of forest stands.

Klamath Physiographic Province occurs in southern Oregon and northern California, where forest conditions are drier than they are further north. The diverse geology and high relief of the region have resulted in exceptional biological richness (Whittaker 1960, 1961, Wallace 1983, Richerson and Lum 1980) and a complex natural mosaic of vegetation and habitats. Species richness of vascular plants is particularly high in the region, including regional endemics and disjunct populations of conifers. The region's serpentine soils have also provided unique habitats that harbor many narrowly endemic herb species.

The natural disturbance regime in the Klamath region includes fires of a wide variety of frequencies and intensities. This has resulted in vegetation patches of various sizes, communities and ages (Swanson et al. 1990). Under natural fire regimes, vegetation patches are smaller and more linear in the Klamath region than farther north or along the coast.

The Influences of Forest Management on Biodiversity

Historically, timber management on KNF emphasized short-term economic value of timber harvest. Changing social values (e.g., Anderson 1988, Caufield 1990, Friedman and Grumbine 1988, Norse et al. 1986) are emphasizing the need to protect wild forests (Noss 1987, 1990) as well as ensure that resource use on multiple-use lands does not degrade productivity, diversity and sustainability of the land (Salwasser 1990). In recent years, scientific studies have provided information on the ecological roles of many components of a natural forest ecosystem, including those of down wood, snags and diverse vegetation structure within stands (e.g., Bormann and Likens 1979, Buckley and Triska 1978, Franklin and Spies 1984, Franklin et al. 1987, Maser et al. 1978, Spies et al. 1988, Ziemer 1981), which is now being incorporated into land management with an emphasis on maintaining long-term site productivity and overall natural diversity.

Within Klamath Physiographic Province, intensive, even-age silviculture has simplified the structure and species composition of some Douglas-fir forests (Marcot 1985). As well, dispersed timber harvest scheduling has led to increased fragmentation of old forests (Franklin and Forman 1987). As landscapes are increasingly modified by human activity, differences in structure and composition between intensively managed forests and naturally functioning forests become sharper. For example, forest stand edges become more linear, with greater structural contrasts, and patches of old, undisturbed forests become small and less well connected (Forman and Godron 1986).

For example, in forests of Douglas-fir and western hemlock (*Tsuga heterophylla*) on Olympic National Forest in Washington, Morrison (1990) reported that in 1940, more than 87 percent of old-growth forest occurred in stands over 4,000 ha in size. In 1988, after several decades of intensive, even-age timber management, only one patch larger than 4,000 ha remained and 60 percent of existing old growth occurred in patches less than 40 ha in size. Similar but less dramatic trends are recognized on KNF when stands in actively managed areas were compared to stands in unroaded reference areas. For mid-seral stages, the average stand size is 30–55 percent smaller, and for late seral stages, 15–25 percent smaller in managed areas of the Forest as compared to unroaded areas. Stand sizes in managed areas are from 14–31 percent larger than those in unroaded areas for early seral stage vegetation.

Another result of forest management activities in recent decades on KNF is a shift in the distribution of forest age classes. Early successional stages have become predominant and later stages have declined in total area. This shift has also occurred more broadly within the coastal Pacific Douglas-fir region of the Pacific Northwest. In this region, total land area consisting of old-growth forest before extensive logging has been estimated as 60–90 percent (Franklin and Spies 1984, Harris 1984). At present, old-growth forest covers only 13–37 percent of the region depending on definitions of old-growth used (Norse 1990, Raphael et al. 1988, Noss 1991). Current estimates of existing old growth on KNF range from 12 percent upwards, depending on definitions (Klamath National Forest unpublished data).

Shifts in age classes of forests have been accompanied by changes in composition and abundance of fauna. In the avifauna of northwestern California, populations of the ground/shrub foraging guild have likely increased and those of the forest-floor, bole-foraging and canopy/air foraging guilds have declined (Raphael et al. 1988). In Douglas-fir forests of coastal Oregon, Hansen et al. (in press) reported that intensively managed forests contained fewer species of small mammals and much lower abundances of birds and amphibians than in unmanaged or lightly managed forests.

A Biodiversity Analysis Approach

Six steps are integral to conservation biodiversity on multiple-use public forest lands.

1. *Identify biodiversity indicators.* General parameters and measurable indicators of biodiversity need to be identified.
2. *State desired future conditions.* To evaluate effects of planning alternatives, clear and measurable desired future conditions need to be specified in terms of values of each of the biodiversity indicators.
3. *Develop standards and guidelines.* A set of standards and guidelines for forest management activities need to be devised that conserve desirable elements of biodiversity and help attain and maintain desired future conditions.
4. *Estimate effects.* Values of each biodiversity indicator need to be estimated for current and predicted future conditions, to be compared with estimated values reflecting past (pre-settlement), "natural" or current "unmanaged" references areas.
5. *Specify decision criteria.* Decision criteria for selecting and implementing a forest planning alternative should include specific criteria for weighing effects on the biological diversity parameters and indicators.
6. *Implement, monitor, adapt.* Implementing a planning alternative should include monitoring selected biodiversity indicators and response of biota and other components of the forest ecosystem. Results should be used to redirect management as needed.

The biodiversity planning effort on KNF will address all six steps. The following discussion focuses on use of biodiversity indicators, development of desired future conditions, and estimation of natural and current conditions.

Biodiversity Parameters and Their Indicators

The complexity of conditions and changes resulting from forest management activities underscores the need to develop clear definitions and parameters of diversity that can be evaluated with consistency. Biodiversity encompasses forest composition and ecological structures and processes at multiple levels of organization (Noss 1990). It is a general concept that begs further definition by identifying specific parameters and measurable indicators of those parameters.

A set of general parameters and specific indicators of biodiversity (Table 1) are used in this project to guide planning at landscape and National Forest scales. Site-specific forest management should also be evaluated to address cumulative effects on biodiversity. Further, optimal use of biodiversity indicators presented here required good forest inventory data and analysis tools such as geographic information systems.

In general, parameters of biodiversity can be classified as compositional parameters that name the elements within natural communities, structural parameters that represent ecological patterns within landscapes and functional parameters that define natural processes (Noss 1990).

Compositional Parameters of Biodiversity and Their Indicators

Vegetation and habitat types. The amount and distribution of vegetation in each seral stage and vegetation type are indicators of forest composition. They describe the current and future availability of plant and animal habitats in all stages of vegetative succession. Depending on the data base available for analysis, this can be assessed by vegetation series, groups of plant associations, or as a proxy, timber strata cross-walked with Wildlife Habitat Relationships (WHR) vegetation classes (*see* Salwasser and Tappeiner 1981).

Describing the amount of vegetation communities in specific age classes is particularly relevant to managing for wildlife species with restricted ranges and habitats (Raphael 1988). Shifts in the amount of vegetation in various age classes will affect wildlife species dependent on specific seral stages or vegetation components such as snags and down wood. Wildlife species of old-growth forests are particularly affected (Carey 1984, 1989, Ruggiero et al in press). The KNF analysis recognizes seven forest seral stages and additional land in non-commercial, non-forested vegetation types.

Species diversity. Species diversity is partially a function of the number of different types of habitats present (Harris 1984); it is also influenced by the biogeography of the species and their habitats. Because it is not tractable to analyze the distribution and abundance of every plant and animal species, a proxy needs to be established to evaluate and monitor species diversity. One example in National Forest planning is the use of management indicator species or communities.

Every species plays a unique role in an ecosystem, but it is not possible to monitor them all. Of highest priority are species and habitats that are rare or declining

Table 1. Indicators of biological diversity for forest planning analysis.

Parameter	Analysis indicators	Existing situation available data
Composition		
Vegetation and habitat types	*Presence or absence of natural vegetation types *Amount of vegetation in each defined seral stage (other = nonforested, noncommercial, barrens)	*Ecosystem classification complete *Seral stage: 1 2 3A 3BC 4A 4BC 5C+ other Percent KNF: 11% 3% 26% 17% 12% 2% 12% 17%
Species diversity	*Management Indicators; key habitat types —Acres of key habitats available —Predictions of the impacts on species diversity	*Incomplete data
	*Potential for invasion or spread of non-native species —ac/ha soil disturbed (timber harvest, road building) —revegetation standards and guidelines	*4153 acres of clear-cut per year *26.5 miles of new road built per year
Sensitive and endemic species	*Status of special emphasis species as assessed by: —management emphasis of special plant/animal habitats —standards and guidelines for species protection —habitat management and species recovery plans	*Special habitats Reg 1 Reg 2 Reg 3 Reg 4 —Serpentine soils 12% 34% 8% 46% —Riparian habitat — — 40% 60% (Reg 1 = timber emphasis; Reg 4 = no timber harvest)
Community diversity	*Management, protection and enhancement of special plant communities such as: —wetlands —crest zones —meadows and glades —minor conifers	 *Riparian management standards *Mapping, describing minor conifer spp stands
Genetic diversity of tree species	*Timber harvest and plantation prescriptions *Managing disease risk and resistance	*Sugar pine seed collection by elev, seed zone *Fungal root rot prevention action plan *Plant using existing and potential species mix

Table 1. (continued).

Parameter	Analysis indicators	Existing situation available data
Structure		
Stand structure	*Management guidelines as affecting key stand features:	
	—canopy density and layering	*Managed for silviculture and/or wildlife values
	—quantity and quality of snags & coarse woody material	*Incomplete data
	—components of herb, shrub and hardwood layers	*Managed for silviculture and/or wildlife values
Patch size, shape; habitat "edge"	*Size of vegetative blocks to be maintained or created	*Weighted avg, all seral stages: 64 ac
	*Stand shape index (0.0 = linear; 1.0 = circular stand)	*Weighted avg, all seral stages: 0.41
Fragmentation	*Amount of "interior habitat" conditions maintained	*Incomplete data
	*Mi/km of roads closed seasonally	*Incomplete data
	*Mi/km of new roads to be built	*26.5 miles of new road built per year, avg
	*Road densities (mi/km per unit of land area)	*2.5 to 3.1 mi/section avg. road densities excluding wilderness and roadless areas
Habitat linkages	*Landscape patterns affecting dispersal and movement	*Complex pattern of inner gorge/riparian areas form interconnected habitat and travel network
	*Land allocations affecting corridor effectiveness	
Function		
Habitat turnover rates	*Percent KNF managed at various stand rotation lengths	*80–100 yrs = 13%; 120–150 yrs = 20%; 240+ yrs = 67%
		*Average 6,450 acres/year
	*Amount of stand-replacing fires predicted per decade	*Generally, maximum supression
		*Incomplete data
	*Fire management and prescription strategies	
	*Predicted rate of insect or disease outbreaks	

continued

Table 1. (continued).

Parameter	Analysis indicators	Existing situation available data
Nutrient cycling and soil productivity	*Removal of snags and down logs for fuelwood	*Minimally restricted
	*Replacement and maintenance of snags and logs	*Site specific projects
	*Area of land burned at low intensity	*Average 10,814 acres/year
	*Management of nitrogen fixing plants and fungi	*None
Fish habitat suitability	*Tons of sediment produced per area of land	*Incomplete data
	*Quality and quantity of key habitat features	*Incomplete data
Human land-use trends	*Hunting and poaching rate predictions	*Incomplete data
	*Recreation intensity	*Incomplete data
Natural function of ecosystems	*Area of land allocated to non-manipulative use	*60% of KNF managed for no timber harvest
	*Land managed at various timber harvest intensities by timber regulation class (1 = primary emphasis; 4 = none)	*Management Reg 1 Reg 2 Reg 3 Reg 4 Percent KNF 13% 20% 7% 60%

(Diamond 1976, Noss 1983) and that function as ecological keystones, influencing presence and abundance of other species. Threatened, endangered, and other special emphasis species and their habitats are important components of species diversity. The status of plan and animal species sensitive to forest management practices are particularly useful indicators. Assessments should address how land allocations, management standards and guidelines, and proposed management strategies will affect viability of these species over time.

Management practices that facilitate invasion of competitive non-native plant species and introduce disease organisms (Schowalter 1988) can also adversely affect desired species diversity. Indicators for this include road density and total area of soil disturbed by timber harvest operations.

Additional, measurable indicators of species status are population parameters. Demographic variables can be monitored. Factors such as abundance, density, reproduction, population rate of change, recruitment, mortality and genetic diversity are important indicators for developing habitat management plans for some species.

Community diversity. Community diversity can be assessed by evaluating potential effects on species diversity from implementing proposed management guidelines that affect specific habitat conditions. On KNF, communities of special concern include wetlands, dry meadows and glades, crest zones, plant communities on serpentine substrates, and plant communities with conifer species of unique character such as Port-Orford-cedar (*Chamaecyparis lawsoniana*) and Pacific yew (*Taxus brevifolia*).

Genetic diversity. Long-term viability of species and health and vigor of populations depend, in part, on adequate genetic variability within and among populations. Species must be able to adapt in response to changes in local environments and global climates. As indicators to genetic diversity and adaptability of plant and animal populations, KNF is assessing size of populations, distribution of current and potential habitat, and potential interchange of genetic material between populations for key species where data are available.

Genetic diversity of conifer trees is directly influenced by timber management programs. Timber harvest and reforestation prescriptions determine the genetic make-up of forests. Types and diversity of stocks selected for regeneration and selection of trees for genetic improvement, including for disease resistance, are indicators of maintenance of genetic diversity of these tree species.

Structural Parameters of Biodiversity and Their Indicators

Stand structure. Even-aged plantations of trees usually lack the structural diversity of native forests and are biologically less rich. Wildlife species associated with large trees, snags and other features of complex, multi-layered stands might be uncommon or even absent from plantations simplified in structure and plant species composition. The complexity of forest structure can be indicated by such stand-level features as canopy density and layering, quantity and quality of snags, course woody material on the forest floor, and components of herb, shrub and hardwood layers.

Landscape vegetative patterns. Horizontal forest structure, or the vegetative patterns making up a landscape, influence suitability of habitat for meeting the needs of individual animals and maintaining populations. On KNF, size, shape and distribution of vegetation patches resulting from management activities are compared to natural patterns as indicators of structural diversity at a landscape scale.

Patch size is particularly important when evaluating old growth as wildlife habitat. Because of penetration of sun and wind at least two tree heights into a forest, patches of old growth below 10 ha in size are essentially all edge and patches several times larger still may not provide adequate interior area to support some species (Harris 1984, Franklin and Forman 1987). Patch shape is generally a greater concern with smaller than with larger patches; smaller and elongated patches have higher perimeter/area ratios than do larger, circular or square patches. On KNF, amounts of edge and interior old-growth forest habitat provided in a landscape matrix are indicators of habitat suitability to wildlife species associated with old forests. Forest interior species that are sensitive to edge effects or require large contiguous or undisturbed areas to maintain populations are unlikely to persist in fragmented or human-dominated landscapes (Noss 1983, Harris 1984, Wilcove et al. 1986).

Forest fragmentation is also a function of roading. Forest harvest strategies that disperse clear-cuts across the landscape require large road networks and tend to maximize fragmentation and the potential for catastrophic windthrow and other negative effects. Some small animals rarely cross roads (Oxley et al. 1974, Mader 1984, Swihart and Slade 1984). For those species, a network of roads fragments populations into smaller units that are more vulnerable to extinction from any number of causes. As patterns of vegetation change, such as from changes in local climates, road barriers could serve to decrease successful movement of such species.

Many wide-ranging animals such as large carnivores and ungulates are habitat generalists and routinely travel through fragmented landscapes. In doing so, however, they encounter a number of threats resulting from road access. In managed forest landscapes, roads provide access to hunters. Hence, road density is often one of the best indicators of habitat effectiveness for large mammals (e.g., Wisdom et al. 1986). Road density (linear extent of roads per unit land area) and length of roads to be built or closed indicate potential effects on animal species sensitive to hunting or presence of forest openings, or with constrained movement abilities. Amount of forest in roadless condition, sizes of forest patches and amount of interior forest area indicate the amount of interior forest habitat available.

Other predictive indicators of effects of forest fragmentation are land ownership patterns, and land exchange policies and priorities. On KNF, consolidation of lands provide greater opportunities for maintaining old forests in less fragmented conditions.

Habitat linkages and connectivity. Most animal species are distributed as collections of local populations linked by dispersal and other movements (Levins 1970). Providing for successful wildlife movement helps maintain population persistence. Movement of individuals between populations must be great enough to balance extirpation of local populations. Patterns and rates of movements, including dispersal of juveniles, are species-specific.

Land allocation patterns and management standards and guidelines influence fragmentation and landscape patterns of forests, which in turn affect success of animal movements and occupancy of habitats. On KNF, land allocations and management guidelines indicate connectivity of forests over broad geographic areas. Habitat conditions in critical travel corridors can be evaluated in specific watersheds as to effectiveness for different species.

Structural contrast between adjacent vegetation patches is another measure of habitat isolation for some wildlife species (Harris 1984). Distances between patches, particularly of forest seral stages that are scarce and critical for an animal's successful movement, can indicate the degree of isolation of habitats.

Comparing land management strategies that will provide the best movement opportunities for most wildlife species is difficult. Two different approaches have been proposed to meet the needs of different species, under different circumstances, and both approaches can be considered in a biodiversity landscape analysis. The first approach entails maintaining a matrix of suitable habitat throughout a landscape as a way to reduce isolation of populations, such as for linking subpopulations of northern spotted owls (*Strix occidentalis*) in the Pacific Northwest (Thomas et al. 1990).

The second approach is to provide distinct linkages or corridors between habitat patches (Diamond 1975, Harris 1984). The corridor strategy has been implemented to link parks and reserves in Florida, but design issues are complex (Saunders and Hobbs 1991, Weins 1989).

Functional Parameters of Biodiversity and Their Indicators

Many ecosystem processes are difficult to identify and monitor.

Habitat turnover rates. Fire is the primary natural process in the Pacific Northwest and on KNF that replaces forest stands. This is particularly true in the Klamath region where fire frequency is naturally high. Harvesting of timber also replaces stands. Harvest rotation length in managed landscapes is one indicator of how closely the function of managed forest stands matches that of stands replaced by fires. Predictive models can be used to estimate rates of ignition and area burned at stand replacement intensity. Predictions of insect or disease outbreak based on forest conditions can also be indicative of stand replacement rates.

Nutrient cycling. Fire also plays a critical role in enhancing cycling of nutrients and maintaining productivity of soils. Frequent low-intensity fires were historically a part of natural conditions in the Klamath Mountains. Reduction in fire frequency has altered this natural ecosystem function. On KNF, the total area, frequency and distribution of prescribed fires of low intensities indicate functioning of the nutrient cycling process. In addition, fuelwood and firewood collecting policies indicate the amount of coarse woody material left on the forest floor which contributes to site productivity.

Presence of nitrogen-fixing plant species and soil microorganisms (mycorrhizal fungi and bacteria) enhance the establishment, growth and survival of many forest plants and plant associations (Atzet et al. 1989). While we currently have no way to directly quantify effects on these site-specific functions at a forest-wide scale, we can assess how well management standards and guidelines might influence presence and distribution of nitrogen-fixers and soil microorganisms on KNF. Guidelines for management of alder and ceanothus species and standards for protection of organic matter in forest soils can serve as indicators of potential effects on these crucial biological functions.

Fish habitat suitability. Fisheries biologists have developed a number of indicators of aquatic health. Many of these indicators cannot be used in a forest plan but can be used in more site-specific management and monitoring activities on KNF. Tons of sediment produced by soil disturbing activities indicate water quality. Indicators of quality of fish habitat are: amounts of fine sediments in streams; numbers and distribution of pools, riffles, and large logs anchored within the stream channel; presence and density of standing trees available as future recruitment to the stream channel; water temperature and amount of riparian vegetation; and presence and densities of populations of invertebrate organisms.

Maintenance of natural ecosystems. Some types of forest management are more likely to provide for natural composition, structure and biological functions to continue than are others. The area of land allocated to various intensities of management provides a general indication of the level at which native forest ecosystems are being maintained.

On KNF, estimates of management intensity are being made using the timber regulation classification system. In this system, lands are allocated at regulation classes 1–4, for primary, co-dominant, incidental or no timber harvest. The amount of land allocated under each planning alternative for wilderness, wild and scenic rivers, endangered species habitat, research natural areas, and other non-manipulative management can indicate the extent naturally functioning communities are being maintained. Currently, 13 percent of KNF is being managed at regulation class 1, primary emphasis on timber harvest, and 60 percent is being managed at regulation class 4, no timber harvest. The role of fire suppression and exclusion are important facets of these land management allocations.

Defining Desired Future Conditions

What are the most desirable future conditions to ensure conservation of biological diversity? We should take our cues from nature when making land management decisions, mimicking the natural systems that have developed over the past several thousand years.

Given this objective, we are faced with a significant land management planning problem: defining "natural" conditions. Some concept of what constitutes a natural forest is necessary to help meet requirements of the U.S. National Forest Management Act of 1976 and subsequent federal regulations, which call for evaluation of diversity as compared to natural and existing forest conditions.

Defining "natural," against which we can compare existing landscapes, is somewhat elusive due to the dynamic nature of ecosystems. Natural landscapes are dynamic entities with changing forest structures and habitat patterns. Even in times preceeding European settlement, native forest landscapes in the Klamath region were a dynamic result of numerous physical and ecological factors. Any static picture of natural conditions, such as by reconstructing native vegetation based on historical records, is simply one frame in a very long movie.

Furthermore, finding areas that directly reflect such natural processes sans humans is difficult. Given the suppression of natural fire in the last few decades, and the use of fire as a vegetation manipulation tool by early settlers and native Americans before them, even unlogged landscapes may not truly reflect forest composition, structure and processes devoid of human influences. Thus, defining desired future conditions and "natural" baseline biodiversity is problematic. One approach on KNF will be to describe current conditions of areas with the least direct human influences, such as roadless areas, to be used as comparative references areas. More discussion and study is needed to define and quantify the conditions that would foster desired, self-perpetuating attributes of biological diversity.

Conclusions and Summary

The forest planning process provides a significant opportunity to address conservation of biological diversity in multiple-use land management. Planning is both the launching point for the future and the process of learning from the past. The ultimate—indeed, the only authentic—measure of success is maintenance of long-term site productivity, sustainability of resource production, and conservation of plant and animal species and communities *on the ground.*

A planning process for conserving biological diversity is being developed and implemented on Klamath National Forest in northern California. The process entails identifying biodiversity parameters and indicators; stating desired future conditions; developing management standards; assessing past and present conditions; estimating effects of planning alternatives; specifying decision criteria for selecting a planning alternative; and implementing, monitoring and adapting management direction.

We have identified an array of specific parameters of biological diversity and a set of measurable indicators for those parameters. Developing desired future conditions for conserving biodiversity is best done by taking cues from naturally functioning forests. However, because of a lack of data, distinct climate changes in the past few hundred years and the influences of native American burning practices, quantifying desired future conditions based on natural or pre-settlement conditions is problematic.

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Trends in Ecosystem Management at the Stand Level

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Introduction

One often hears that we are in or on the verge of a "New Forestry" in which the philosophy, perspectives and practices of forestry become more ecologically and socially sensitive (Gillis 1990). Actually, forest management has always been in a state of change—the term "new forestry" was first proposed in the early 1900s to describe practices of German plantation forestry that were become popular in England and parts of North America (Simpson 1990 *in* Savill and Evans 1986). Over the last century, human use of forest has often developed along two divergent lines: plantation forests primarily for timber production, and wilderness and reserve forests for recreation and other social and ecological values. However, as forest values have increased and diversified on a fixed or declining forest land base, it has become clear that dividing up the forest into plantations and preservations may not be the best way to provide for the diversity of human needs associated with forests (Franklin 1989). Consequently, a third more-recent perspective has developed, termed "ecosystem management," in which forests are viewed as more than timber crops, and forest preserves are viewed as only one part of the solution to the problem of maintaining biological diversity and aesthetic values in managed forest landscapes which provide many values.

In this paper, we will provide a concept of ecosystem management as it applies to forest stands, identify some major trends and give some examples of new approaches either being planned or currently implemented. Our scope will be coniferous forests of northwestern North America, including British Columbia, Washington, Oregon and California.

Ecosystem Management Concepts

The ecosystem concept (Tansley 1935) has existed for over 50 years, and the idea that forests should be managed as ecosystems has been around for at least 20 years

(Van Dyne 1969). Many managers, scientists and the public recognize that forests should be managed as ecosystems, with outputs and conditions measured by descriptors such as soil, plant and animal productivity, diversity, and a broad range of products and values, including timber, fish and wildlife, as well as water quality, and recreation. However, practice often differs from theory and legislation (Salwasser and Tappiener 1981), and there are a variety of perspectives on what constitutes ecosystem management and how it should be implemented (Graul and Miller 1984, Franklin et al. 1986, Johnson and Agee 1988, Perry 1989). A full discussion of ecosystem management is beyond the scope of this payer. However, we highlight some of the major concepts below.

Complexity

Ecosystems are characterized by a diversity of biological and physical components tied together by a complex set of relationships. When forests are managed primarily for tree crops, relatively few components are considered explicity—often just wood fiber production and soil productivity. In broader ecosystem management many components such as non-game vertebrate and invertebrate species, shrubs and non-woody vegetation, hydrology, aquatic and soil animals and processes, and recreation are to be considered. The relationships among components can be quite complex and characterized by organismic responses, and flows of material and energy that include time lags, cumulative effects and non-linear relationships. The basic challenge of ecosystem management is to consider the broad diversity of components and apply manipulations to organisms and structures in ways that minimize undesirable ecosystem effects.

Ecosystem management can be viewed as manipulation of complex ecological structures including ecosystem structure, habitat structure and stand structure. Ecosystem structure is the kind and variety functional ecosystem components and linkages among them (i.e., foliage, detritivores, herbivores, and energy and nutrient pathways). Habitat structure, in a broad sense, is the kind, size and spatial distribution of live and dead organic matter and physical site conditions that are important for the growth and reproduction of organisms. Stand structure is primarily the kind, size and spatial distribution of live and dead forest vegetation. Obviously, there are overlaps and close relationships among these types of structure. In practice, forest ecosystem managers typically manipulate stand structure to meet management objectives including habitat and ecosystem structure and function.

Spatial Variation

The ecosystem is a "one size fits all" concept—an ecosystem can be the inside of a fallen tree or encompass a mountain range or an entire planet, depending on the components of interest. Stands, the traditional focus of forest management, can be viewed as patches of a larger ecosystem and at the same time as an ecosystem comprised of heterogeneous mosaics of finer-scale ecosystems such as fallen logs, canopy gaps and unique soil/topographic features. Where wide-ranging species and broad-scale processes are of interest, management activities at the stand level may be subordinated to conditions of the surrounding landscape.

Management of Change

Change and uncertainty are inherent in ecosystem management. Ecosystems are dynamic and change as a consequence of relatively predictable processes, such as succession and stand development, and less predictable processes, such as wildfire, wind, insect outbreaks and climate change. Since many organisms and processes are adapted to natural disturbances, many ecosystem objectives are achieved through imitation of natural disturbance regimes (Hunter 1990). Ecosystems, at stand and landscape levels, are not equilibrium systems, consequently, long-term sustainability of some or perhaps all of their components will not be possible (Botkin 1990). This means that our desire for a constant flow of products or a constant proportion of ecological conditions must be tempered to allow fluctuations in the ecosystem.

Sources of uncertainty in management include: (1) imperfect knowledge of ecosystem processes and management effects; (2) climate change; (3) management practices that are not implemented as desired; and (4) changing social systems and values. All of these sources of uncertainty require that ecosystem management also be adaptive management (Walters 1986), allowing for corrections through monitoring and feedback to management.

Why Practice Ecosystem Management?

At least three motivations exist to practice ecosystem management: (1) more future options may be kept open, and management forest ecosystems may be more resilient to unexpected changes than when management has a narrower focus; (2) managing for whole systems, subsystems or guilds will be more efficient and realistic than if every individual species or process receives separate attention; and (3) where information is particularly lacking about a particular ecosystem component, natural ecosystems provide a valuable interim model until more specific management practices can be developed.

Stand Management Alternatives to Achieving Ecosystem Objectives: The Case of Old-growth Management

No single stand management practice is adequate to maintain the diversity of patch types and successional pathways that occurred in natural forest landscapes. We illustrate four management alternatives that could be used to create individual old-growth features in younger stands or imitate entire old-growth stand structures (Figure 1). Old-growth is used as an example because it is currently a critical issue in many parts of British Columbia and the United States and influences many current and planned management activities. Our use of old-growth as an example does not mean that management for features or stands is the only ecosystem management objective. However, management for old-growth characteristics does meet a variety of objectives including wildlife habitat, recreation, large-size timber, water quality, stream habitat, and aesthetics.

Old-growth management has often meant identifying old-growth stands to prioritize their cutting or to put them into reserve status. However, where little old-growth exists, as a consequence of natural or human disturbances, it may be desirable to passively or actively manage for old-growth features and stand structures (Nyberg et al. 1987). In managing for stand structure we assume that the relationships to habitat structure and ecosystem structure are at least generally known. Mature and old-growth stands which developed after fire and windthrow can be used as models for the desired structure of managed older stands (Spies and Franklin in press). Several practices could produce old-growth structures and whole stands that imitate old-growth.

Passive or Minimal Management Activity

Plantations or naturally regenerated stands will develop into old-growth given a long enough period of time (Figure 1, alternative I), assuming no intervening disturbances. However, stand structure may not be exactly the same as current old-growth stands (Spies and Franklin 1988a) because of differences in disturbance and stand history. In some cases it may be desirable to manage stands on very long rotations or, perhaps, on "natural" rotations, in which the stand is allowed to grow with minimal intervention and natural disturbances are allowed as long as the current and projected stand conditions are desirable. If disturbances or succession alter the structure of the stand, manipulations could redirect it back toward the desired conditions. Management activities during the life of the stand may include thinning, protection from disturbance, planting or use of prescribed fire to imitate "natural" conditions.

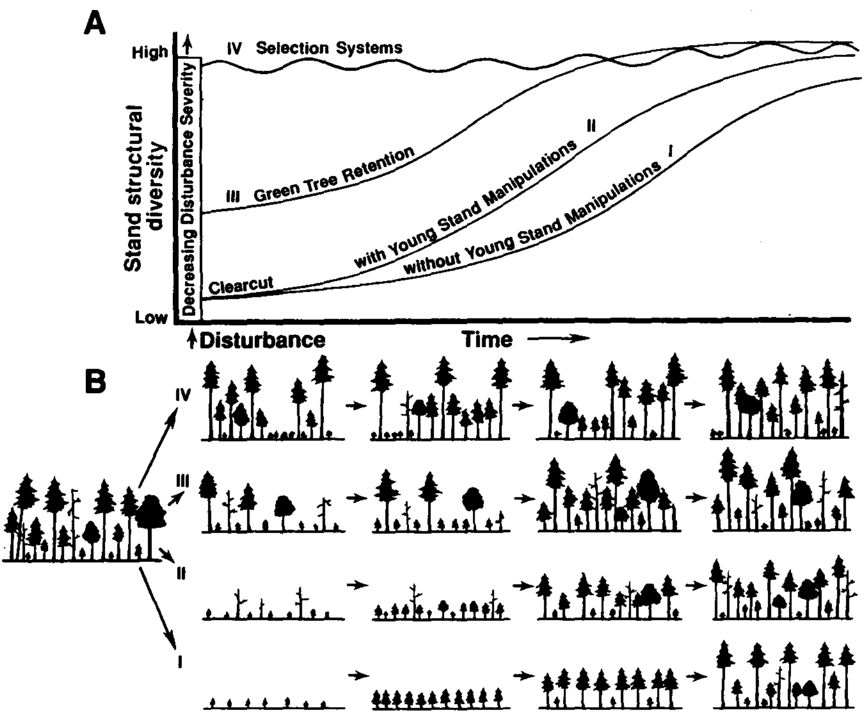

Figure 1. Alternative methods (A) (I–IV) to produce structurally diverse stands (B) that contain individual old-growth features or imitate the structure of natural old-growth stands.

Diversifying Young and Mature Stands

Several sivicultural activities can accelerate the development of old-growth characteristics in young stands (Figure 1, alternative II). Planting density, precommercial thinning and vegetation control early in stand development will have a major effect on species composition and structure throughout the life of the stand. Density control will ensure that desired species are not excluded because of competition. It appears that some natural developmental stages can be accelerated or skipped (Ashby 1987) through stand manipulation, and thereby shorten the period of time needed to develop later developmental stages such as old-growth. Precommercial thinning will prevent or delay the stem exclusion stage of succession (Oliver 1981) and prolong early seral species well into the life of a stand. Hardwoods can be grown in groups so that overtopping by conifers will not reduce their vigor or potential mast production. Grouping of hardwoods and thinning conifers to variable spacing will enhance horizontal structure—the patchiness of both trees and shrubs—and vertical structure by their effect on crown diameters and live crown ratios.

Commercial thinning can be used to further direct structural development. It maintains large, live crowns in the overstory and favors establishment and growth of new conifers, shrubs and hardwoods (Fried et al. 1989). Depending on the site, species, age and the presence of root diseases, thinning might increase the likelihood of windthrow. One important effect of judicious commercial thinning will be maintenance of vigorous stands, thus extending rotation length. Western conifers generally grow well at advanced ages, and given proper spacing, can remain productive well-beyond 100 years of age (Newton and Cole 1987). Current growth models also suggest that culmination of mean annual increment of western conifers can be extended by commercial thinning (Curtis et al. 1981, Hester et al. 1990). Thus, commercial thinning as the potential for maintaining a high degree of species diversity, growing large trees and encouraging merchantable wood production at advanced ages—thereby providing some elements of late successional forest ecosystems.

Where windthrow is not a major problem and the terrain is suitable to logging systems, green tree retention (Figure 1, alternative III) can provide timber products and allow old-growth characteristics to redevelop in a shorter period of time than with either of the first two alternatives. Harvest and site preparation practices can be modified to insure that large conifer and hardwood trees, snags, and logs on the forest floor are maintained in order to provide a carry-over of structural components for many decades or even centuries into the future stand(s). The stand will then consist of two or three age/size classes. Several different regimes are possible, ranging from simple long rotations to mixed age, layered stands. Pure or mixed forest stands can be produced by combinations of natural regeneration, planting and saving advanced regeneration.

Uneven-aged Stands

Where the site conditions, current stand structure, and species mix allow, selection systems (Figure 1, alternative IV) can be used to maintain old-growth characteristics. While selection systems have the advantage of maintaining high canopy cover and structural diversity, they may have other disadvantages. For example, fuels and fire management, disease control, and minimizing soil compaction effects may be difficult in these types of stands.

The different management scenarios are all likely to achieve old-growth stand structure given enough time. Some old-growth features can be produced in a relatively short period of time but a complete old-growth stand structure will require considerable time. The alternatives presented in Figure 1 can be applied in different combinations, creating even more options. Alternatives I, II and III (Figure 1) will also provide for some ecosystem objectives related to early successional ecosystems. Implementing these systems, especially green tree retention, will require stand specific analysis of: worker safety; fuels and fire management: logging systems layout; pathogen and insect effects; animal populations; costs; as well as stand development and yield.

Regional Issues and New Approaches

As mentioned above, a difference often exists between theory and practice on the ground. In this section, we briefly survey some current regional issues and trends. We discuss them in the context of five subregions, moving from north to south first within coastal areas and then north to south within interior areas. In all of these subregions many aspects of forest stand management have been partially ecosystem based since the mid-1970s. These are mostly post-harvesting activities, centered on regeneration and site preparation and based on ecosystem or plant association classification such as the biogeoclimatic ecosystem classification of British Columbia (Pojar et al. 1987) and the plant association of U.S. Forest Service land (Franklin 1979). These classifications might serve as a basis for management of ecosystem structure and dynamics.

Coastal Forests of British Columbia

Current harvesting in coastal B.C. forests is almost exclusively clearcutting of old-growth stands. Individual cutting units vary in size from 12–500 acres (5–200 ha) and have been more or less continuous in many areas, with only a short time interval between adjacent cuts. In accordance with Workers Compensation Board regulations, all snags are felled during the harvesting process. A practical way to sidestep these regulations and provide a continuing supply of snags and largely woody debris, would be to leave patches or strips of forest behind in the units.

Management of the remaining old-growth is probably *the* forest management issue in coastal British Columbia. Although old-growth is but a part of the larger issue of biological diversity, the spotlight of public and management concern has been mostly on old-growth (Fraser 1990). The discussion and debate have been based largely on facts and opinions from the northwestern United States, and focused on southwestern British Columbia (Pojar et al. 1990). In that regard, maintenance of coarse woody debris seems to be an issue with many people, but would appear to be a real problem mainly in the drier, low-elevation forests of southwestern B.C., which are ecologically similar to the forest of western Oregon and Washington. Wetter and higher elevation coastal stands often have a superabundance of coarse woody debris as well as thick (> 4–8 inches: 10–20 cm), wet, surface organic layers. Considerable dead wood remains after harvesting old-growth stands—72 tons per acre (161 tonnes/ha) on a typical site in the Coastal Western Hemlock (*Tsuga heterophylla*) zone (Meidinger and Pojar in press). Following broadcast burning 28 tons per acre (63 tonnes/ha) remained, of which 26 tons (59 tonnes) was in size classes greater than 2.8 inches

(7 cm) (Douglas 1989). Forest floor depths averaged 4.7 inches (12 cm) prior to the burn and 3.5 inches (9 cm) thereafter.

Public pressure has stimulated some initial, exploratory efforts in partial cutting and alternative silvicultural systems. As part of the provincial Old-Growth Strategy, a Management Practices Subcommittee is (1) defining ecological attributes of old-growth that will be imitated in the managed forest, (2) exploring means by which old-growth attributes and values can be maintained or created in the managed forest, and (3) determining the extent that old-growth attributes are required in the managed forest.

Since 1980, several innovative approaches to wildlife management have been developed through integrated wildlife/forestry research projects, including ecosystem management for deer (*Odocoileus hemionus columbianus*) and elk (*Cervus elaphus*) habitat (Nyberg et al. 1989) and grizzly bear (*Ursus horribilis*) habitat (Hamilton et al. 1986). Although research and management initiatives have focused on high-profile mammal species, ecosystem concepts have been used as a basis for habitat management. For example, in management for deer habitat (Nyberg et al. 1986, Bunnell and Kremsater 1990), young stands are diversified by manipulating stand density and gap size to promote arboreal lichen production and growth of understory vegetation, reduce snow cover, and provide thermal cover.

Coastal Washington, Oregon and Northern California

The major issues and new management activities on federal forests are related to providing semi-natural and late successional stage ecosystems and maintaining the structure and function of streamside ecosystems. Until recently, clearcutting areas of 10–60 acres (4–24 ha) followed by planting, has been the predominant timber management practice on federal lands. On private lands clearcuts are often larger than on Federal lands and rotations are typically 40–60 years.

In the last 10 years, new management objectives on federal lands have included coarse woody debris and diverse stands. Hence, green tree and woody debris retention have become "standard practices" on federal forests and are being tried on some industrial forest lands. Typically, one to five large live green trees are left per acre (2–12/ha) and removal of coarse woody debris following cutting has been reduced. Large snaps are left where safety requirements allow. The green trees add structure to the next stand in the form of live trees, snaps or large fallen trees. Rotations of 70–120 years are planned for these stands, with the intent of leaving some of the plantation trees at the end of the rotation to provide future structural diversity. Some companies are commercially thinning young-growth stands but this practice has not yet been widely implemented. Westside forest typically have well-developed understories of shrubs and hardwoods which generally preclude the establishment of natural, advanced, conifer regeneration on many sites. Also, terrain is generally steep, so management systems have to be relatively simple. Because of these factors, it will be much more difficult to work with complex structures on steep slopes than it will be on the gentler terrain of the drier eastside forests. Helicopter logging may play a greater role in the future especially where wood values are high enough to make the operation cost effective.

Westside forest have millions of acres of well-stocked plantations 5–30+ years of age. Many of them have received early precommercial thinning and are stocked with vigorous trees. They are amendable to developing a variety of stand structures.

Several commercial thinnings beginning at early ages will enable these stands to provide large, full-crowned trees and develop a shrub and hardwood understory while yielding wood products over a long rotation (Staebler 1960). On one site, stands thinned to 50 Douglas-firs (*Pseudotsuga menziesii*) per acre (124/ha) at 40 years of age and planted with western hemlock have produced a well-developed second layer by 70 years. Openings occur naturally in root disease centers and pockets of windthrow which provide snags, woody debris and sites for development of shrubs, and tolerant hardwoods. This type of ''small scale'' disturbance can be simulated by harvesting trees from small groups (0.5 + acre) and possibly strips. These openings can be regenerated with Douglas-fir, western hemlock and possibly red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and tanoak (*Lithocarpus densiflorus*), vine maple (*Acer circinatum*), salmonberry (*Rubus spectabilis*), thimbleberry (*Rubus parviflorus*), salal (*Gaultheria shallon*) and other shrubs, thus adding to structural diversity; shrub and hardwood control will be needed to ensure conifer regeneration.

Where logging occurs near streams, buffer strips are often left to provide woody debris for stream habitat and shading to control stream temperatures. The long-term stability of buffer strips is an area of concern. Eventually, in many streamside stands conifers may have to be planted where natural regeneration is not occurring, which is often the case because of competition from shrubs and hardwoods. In those situations, planting tall seedlings (1–1.5 meters) along with vegetation and rodent control may be required to maintain stand structure and inputs of large wood to the stream.

Central and Northern Interior of British Columbia

Large live trees and snags are an important part of the habitat structure in interior as well as coastal forests. Some 87 animal species use snags for habitat or as a food source in British Columbia. Deciduous trees, such as trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*) and black cottonwood (*Populus trichocarpa*), are used by cavity-nesting birds in interior B.C. forests, more often than conifers (Keisker 1987). This is not the case in coastal old-growth Douglas-fir forests, where conifer snags are the major or only habitat source for cavity nesting species.

The role of large woody debris in northern forest ecosystems is not well understood. There is little doubt that woody debris provides habitat for a variety of forest organisms. Quantities of woody debris and reserves of forest floor organic matter vary considerably within mature forests of spruce (*Picea* spp.), lodgepole pine (*Pinus contorta*) and subalpine fir (*Abies lasiocarpa*) of northern central B.C., depending on climate and local moisture conditions. For example, woody debris averaged 7 cubic yards per acre (13 m^3/ha) on dry sites, 135 cubic yards per acre (255 m^3/ha) on mesic sites and 174 cubic yards per acre (328 m^3/ha) on wet sites on western central B.C. (Lofroth 1991). In addition to the woody debris, forest floor depths average 1.1 inches (3 cm) or 16 tons per acre (36 tonnes/ha), 3.5 inches (9 cm) or 48 tons per acre (108 tons/ha), and 5.9 inches (15 cm) or 90 tons per acre (1980 tons/ha) on dry, average and wet sites, respectively. In contrast, old-growth Douglas-fir forests of western Washington and Oregon average 166 cubic yards (313 m^3/ha) of fallen tree boles (Spies et al. 1988b). In coastal Douglas-fir stands forest floor depths average about less than 1 inch (2 cm) in old-growth forests (Spies and Franklin in press) as a consequence of relatively rapid decomposition and variable-intensity fires.

The issue of retention of coarse woody debris and organic matter reserves, and their role in maintaining long-term site productivity, seems less urgent in subboreal and boreal ecosystems, at least in the present initial harvesting cycle. Not only do the moist cold soils benefit (in terms of tree productivity) from some removal or mixing of the surface organic matter, but also, on most sites, post-harvest residues are substantial, even after broadcast burning. To a certain extent, forest harvesting imitates the natural, stand- destroying disturbance regime of these forests, although logging and slash-burning usually leave little standing and also remove much coarse woody debris and some forest floor from the site, so the long-term effects of present practices are still a concern.

Prior to the early 1970s, most harvesting/regeneration methods in the central and northern interior were either single-tree or group selection, diameter-limit, or strip logging. With changes in sawmilling technology and the establishment of a pulp industry, large-scale clearcutting became the norm by the mid-1970s and currently less than 1 percent of the area harvested is by methods other than clearcutting (Ministry of Forests 1989a). There is renewed interests in earlier methods used prior to clear-cutting. They resulting in structurally diverse stands, but often failure to achieve regeneration, resulting in extensive blowdown, and were thought to have increased insect and disease problems. Trails and experiments are just beginning on alternatives to clearcutting that achieve structural diversity and desired regeneration levels, and mitigate against windthrow and pest problems. At an operational level, it is becoming more common for deciduous trees to be left standing in cutting units. Horse logging is increasingly being recommended for environmentally sensitive areas and areas where some level of green tree retention is prescribed. It also is common practice to plant two or more crop trees species and to leave several tree species during early stand tending.

Southern Interior Forests of British Columbia

In the Interior Douglas-fir, Ponderosa Pine (*Pinus ponderosa*), Montane Spruce, and Interior Cedar—Hemlock zones (Meidinger and Pojar in preparation), 15–20 percent of all stands in 1988–1989 were regenerated seedtree, shelterwood or selection methods. Even so, the use of clearcutting increased in the five-year period from 1984–1989, in the face of increasing public opposition to the practice.

Management of old-growth forests is of increasing concern, especially because of their role in wildlife habitat and in water management—an especially important issue in the dry southern interior. Snags as wildlife habitat are also an issue in the interior, especially in the dry forests of the southern interior where snags are a diminishing resource in some forest types (Harcombe 1988).

Partial cutting systems (shelterwood, group selection and single tree selection) are commonly used in the southern Interior and their use is expected to increase, especially in visually sensitive landscapes and where important wildlife habitat is involved (e.g., Armleder et al. 1986). Resource planning guidelines in the south-central interior (Ministry of Forests 1989b) now invoke special considerations for planning zones such as community watersheds, ungulate winter range, riparian ecosystems and lakeshores. The harvesting guidelines for these zones generally call for partial cutting and/or reduced cutting unit size, with additional recommendations for buffer zones and unit shape, pattern and timing.

Interior Forests of Washington, Oregon and Northern California

The mixed-conifer/true fir and pine forests offer a range of possibilities quite different from the Douglas-fir and hemlock forests of the west of the Cascades Mountains. These forests typically occur on drier sites with generally less vigorous components of shrubs and hardwoods. Fire suppression and individual tree logging have resulting in stands with different structure than would have developed under natural disturbance regimes. Often, the natural regeneration is primarily of shade tolerant true firs and Douglas-fir. Insect and pathogen populations are of major importance in managing these forests; they include mountain pine beetle (*Dendroctonus ponderosa*) in pure lodgepole pine, to spruce budworm (*Choristoneura fumiferana*), mistletoe (*Phoradendron* spp), annos root disease (*Fomes annosus*) and larch casebearer (*Coleophora laricella*) in the mixed forests. Here, forests with diverse structure and species composition do not appear to have mitigated against pathogens and insects, although these biological disturbances may be partially related to the structure of the stands. A combination of relatively dry sites, the lack of light ground fire, the resulting increase in stand density, and amount of tolerant species may have contributed to increases insect and pathogen populations.

Silvicultural practices in these stands, especially on federal lands, seem to have embraced many stand-level "New Forestry" concepts for several years. Uneven-aged management, use of advanced regeneration, thinning to reduce susceptibility to bark beetles and maintaining diverse structure are common practices. Probably the biggest challenges will be to determine how to use fire or replicate its natural effects, and how to work with the wide array of pathogens and insects. The recent, large wildfires and clearcuts of the 1970s and early 1980s have created many areas of relatively simple, early successional stands. Perhaps a prescribed fire regime or thinning could be used to set development on a course toward structurally diverse, yet vigorous older stands.

Conclusions

The practice of ecosystems management is continually developing in response to changes in social and economic values, scientific understanding, and management objectives and technology. Silvicultural options are available to create a greater diversity of managed stand ecosystems than is traditionally found in many managed forest landscapes. Providing a greater array of stand types based on structure, composition and disturbance regime can help to meet many different ecosystem objectives. The development of structurally and functionally diverse stands is one of the major new directions in stand management, particularly in moist coastal forests in British Columbia and in Northwestern United States, where short rotation clearcutting has been the dominant timber management activity. Several alternatives exist to create structurally diverse stands in these coastal types, including long rotations, diversified young plantations and green tree retention. Group selection may be an option on some sites.

In cold, moist northerly ecosystems, where decomposition is a limiting factor in autotrophic productivity, soil disturbances from logging and slash burning may actually improve productivity. However, maintaining a diverse stand structure through retention of green trees is still important to maintaining habitat structure.

On drier interior forest types, the traditional silvicultural systems, involving various types of partial cuts have often resulted in relatively diverse forest stands, although clearcutting has become common in some areas. The drier interior types may be ecologically more amendable to development of structurally diverse stands. Future ecosystem management in drier forest types will involve controlling density in stands through thinning and prescribed fire to imitate natural disturbance regimes and maintain more natural stand structure and vigor.

From British Columbia to California, the continuing challenge to ecosystem management is to create variety of ecologically and operationally viable stand structures by implementing silvicultural practices that imitate natural disturbance regimes. This does not mean that we know enough about these disturbance regimes or ecological structure-function relationships to dispense with reserve areas or passively managed ''natural rotation'' stands. These stands will continue to be important in maintaining biological diversity and ecosystem function in managed landscapes. However, we can apply many of the lessons we are learning from natural ecosystems to managed stands and increase the probability of sustaining ecological values through time.

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Silviculturists and Wildlife Habitat Managers: Competitors or Cooperators?

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Introduction

The objectives of this paper are to describe attempts at providing special habitats for five forest-dwelling wildlife species in British Columbia, and to outline some challenges facing silviculturists and wildlife habitat managers in making these attempts part of normal forest management. These five species have in common their requirements for components typical of old-growth forests, and so pose timely challenges to integrate wildlife and forest management.

The current controversy over preserving old-growth forests tends to overshadow the fact that most forests will be managed at varying degrees and in different ways (Thomas 1985). Also, although old-growth-dependent wildlife species will be afforded some security within reserved areas, it is unlikely that enough old growth will be protected to meet viability and other management objectives for most species. The question arises: What happens to these species in managed forests of the future since, regardless of resource emphases or priority uses, these managed forests can and will continue to produce timber products, wildlife and other resources? The answer depends partly upon the management objectives for the species (and the forest), as determined by social, economic and political considerations, and partly upon the resource managers' capability to provide the habitat attributes in kinds and amounts that these species require (Nyberg et al. 1987). In turn, this capability will be determined by how well the habitat requirements can be specified and by how well they can be accomplished. Species requiring components of old-growth forests will likely place special demands on resource managers because their habitat requirements may not be well understood or, if known, not readily met by traditional forest management practices, Although many disciplines are involved in managing these species, key responsibilities for providing habitat fall clearly on the wildlife habitat biologist and the silviculturist. Their willingness to try is the critical link between these steps. In this paper, silviculture is defined as: ". . .applied forest ecology—a means for protecting and enhancing range, wildlife, water, and soil resources, as well as timber crops. It is the manipulation of forest vegetation for human purposes" (Wenger 1984:414).

Case Study I: Winter Range Creation for Black-tailed Deer (*Odocoileus hemionus columbianus*)

On the southern coast of British Columbia, the need to provide a continuing supply of winter range for black-tailed deer has led to conflicts between wildlife and forestry managers. Certain old-growth timber stands, of high commercial value, provide critical winter habitat during deep snows (Bunnell and Jones 1984). Consequently, many of these stands have been temporarily deferred from harvesting (British Columbia Ministry of Environment and Ministry of Forests 1983). To help solve this conflict, it has been suggested that old-growth winter ranges could be replaced by creating winter range in second-growth stands (Nyberg et al. 1986).

During severe winter conditions, black-tailed deer prefer old-growth forest habitat over early successional stages. Thus, they appear to prefer overstory cover that provides a warmer environment and lower snow depths than in clearcuts. Low snow depths are important because snow increases the energetic cost of locomotion (Parker et al. 1984) and buries forage (McNay and Doyle 1987). Characteristics of ideal old-growth winter ranges have been described by Nyberg et al. (1987). Typically, they are situated on southerly aspects at elevations less than 2,600 feet (800 m), presumably because of decreased snow deposition and increased snow ablation. The overstory consists of Douglas-fir (*Pseudotsuga menziesii*), >200 years old with an average canopy of 65–70 percent to intercept snow. The understory is dense, with thickets usually consisting of western redceder (*Thuja plicata*) or western hemlock (*Tsuga heterphylla*), to provide thermal cover. Forage is supplied by abundant arboreal lichens (*Alectoria, Bryoria, Usnea* spp.) and perennial shrubs—commonly salal (*Gaultheria shallon*) and huckleberry (*Vaccinium* spp.).

Silvicultural prescriptions for creating the above-described attributes of old-growth winter ranges in young-growth are presented in Nyberg and Janz (1990). In summary, the general prescription is to select a young (ideally, 10–20 years old) stand of Douglas-fir >75 acres (30 ha) in area, with some western hemlock or western redcedar, a canopy closure of <70 percent abundant shrubs in the understory, a nearby source of arboreal lichen, and suitable topography. On 60 percent of the site, thin initially to 200 stems/per acre (500 stems/ha) or less, then thin again to maintain canopy closure of < 70 percent until the canopy intercepts snow effectively; then thin to maintain a canopy closure of 70–90 percent. On 30 percent of the site, create open snow interception cover as above, except maintain canopy closure of 60–70 percent. On the remainder of the site in suitable locations, create small, scattered openings (e.g., root-rot pockets, rock outcrops) and understory thickets (e.g., natural regeneration of western hemlock or western redcedar). Detailed prescriptions for the spatial arrangement of attributes within the stand are provided in Nyberg and Janz (1990).

As part of a cooperative research program involving the Ministries of Environment and Forests and private forest companies, a total of six stands (350 acres: 142 ha) have been treated using these prescriptions to demonstrate and test winter range creation methods. Long-term monitoring plans are in place (Heath et al. 1989). In addition, several forest companies have undertaken their own trials (L. D. Peterson personal communication: 1990).

Although the creation of black-tailed deer winter range in young-growth forests has the potential to help resolve an important wildlife/forestry conflict, there are several unknowns about the technique's effectiveness (Nyberg et al. 1987). Although lichen litterfall is a consistent, and possibly necessary attribute of old-growth winter ranges, these specially treated stands may not produce lichen in sufficient abundance for wintering deer. If not, treated winter ranges may not function effectively. Also, it is unclear how long it will take deer to learn to use these managed winter ranges after their old-growth ranges are harvested. Another problem is that suitable stands for treatment are difficult to find because of an extensive history of logging. Although further research and monitoring obviously are needed to help answer these questions, research to date has improved managers' ''level of comfort'' about this approach and resulted in some attempts to find solutions to the old-growth/deer winter range dilemma.

Case Study II: Managing for Attributes of Mule Deer (*Odocoileus hemionus hemionus*) Winter Range Through Partial Cutting

In the Cariboo Forest Region in the central interior of British Columbia, over 618,000 acres (250,000 ha) of Douglas-fir forests have been identified as winter range for mule deer. Resource conflicts have developed because the forest types required by mule deer also have substantial timber volumes. Until recently, the only two options available to managers were conventional harvesting using clear-cutting or high volume partial cutting, which reduced winter range quality, or preserving areas from harvest for deer habitat, which reduced the wood supply. These unacceptable single-use options led the Ministries of Forests and Environment to explore other solutions through a long-term research program.

Initial efforts concentrated on identifying the habitat features mule deer need on winter ranges. A multi-layered stand with a good representation of large, old trees meets those requirements. The mature and overmature trees provide the major winter food through foliage litterfall (Dawson et al. 1990) and intercept the most snow. Younger trees surrounded by a mature or overmature canopy provide the necessary thermal cover, and three to seven feet (1–2 m) tall regeneration gives security cover. Research also revealed that micro-topography is important to deer. Ridges and warm slopes are more valuable than gullies and cool aspects. Thus, the winter requirements of mule deer are met by a mixture of stands of various levels of crown closure on the appropriate topography, but all having a multi-layered stand structure.

An integrated management system was designed to maintain these habitat features (Armleder et al. 1989). The system features low-volume partial cutting (typically about 20 percent of merchantable stand volume) to maintain substantial levels of crown closure perpetually. Typically, small groups of trees are cut rather than uniformly distributed single trees because the remaining clumps of trees are more valuable to deer for snow interception. Tree cover on ridges and southerly aspects is essential to deer and, hence, those areas are logged very lightly, while gullies and northerly aspects, which are the best tree-growing sites, are logged more heavily. Trees of all merchantable sizes are harvested to retain an uneven-aged stand structure with a significant component of large, old trees.

Other features of the system ensure a healthy stand remains that can be harvested again in 25–40 years with the same low-volume approach. For example, non-commercial thinning changes dense, little-used clumps of regeneration into fewer, faster growing trees to provide future deer habitat and timber harvest. How it is done is unconventional and includes: reducing slash depth and changing slash distribution to allow animal movement; leaving unspaced strips to provide thermal and security cover; and modifying crop tree selection to encourage small clumps of snow-intercepting trees.

Government foresters and wildlife managers, as well as forest industry managers have endorsed this integrated management option. This acceptance was due in part to their involvement in the research project from its inception, largely through an advisory committee. Researchers emphasized the presentation of the integrated option in handbook and pamphlet formats rather than giving managers highly technical papers (Armleder et al. 1986). Field-oriented training sessions involving managers and loggers in demonstration stands took the mystery out of the new approach. To date, wildlife managers have produced management plans for 30 winter ranges which incorporate this integrate approach, and they intend to produce plans for all winter ranges in the region (M. Beets personal communication: 1991). After review and approval by forest managers, these plans will guide forest and wildlife habitat management on mule deer winter ranges in the Cariboo Forest Region.

Case Study III: Forage Production for Coastal Grizzly Bears (*Ursus arctos*)

The Coastal Western Hemlock Biogeoclimatic Zone (Pojar et al. 1987) of mainland British Columbia supports some of the highest grizzly bear densities in Canada. Floodplains and lower slope fans are very productive forests sites and are heavily used by grizzlies (Hamilton 1987, Lloyd 1979). In addition to using the natural habitats on these sites, grizzly bears feed in clearcuts for the first few years after logging, and bed and feed in post-logging deciduous forests (Hamilton 1987). Consequently, grizzly bear forage lost through logging of old growth can be partially replaced by productive shrub and deciduous, tree-dominated young forests. Most past attempts to regenerate free-growing conifers on these floodplains and lower slope fans have been unsuccessful, generally because of competition from deciduous shrubs and trees. Now, however, the increasing emphasis of intensive silviculture to grow vigorous conifer stands is in conflict with the maintenance of forage for grizzlies, since coastal closed-canopy conifer plantations have limited understory production (Alaback 1984). Also, herbicides, species conversion and other vegetation management techniques directly decrease forage supply. Thus, depending on the proportion of the landscape covered by closed-canopy young growth conifer stands, the capacity of a watershed to sustain grizzly bears may be reduced (Hamilton et al. in press).

To help integrate grizzly bear habitat requirements and silviculture, some initial recommendations have been developed as part of a study examining the impacts of herbicides on forage production of Coastal Western Hemlock Zone floodplains (Hamilton et al. in press). These include: managing for ''gaps'' in the canopy by relaxing regional stocking standards on some floodplain sites; avoiding herbicide treatment of bear forage species not competing directly with crop trees; and using alternative silvicultural methods such as (1) cluster planting of conifers with selective herbicide treatment and pruning as required, (2) mixed-wood planting (combinations of red alder (*Alnus rubra*), black cottonwood (*Populus balsamifera* spp, *trichocarpa*), Sitka spruce (*Picea sitchensis*), and western redcedar with and without spot herbicide treatments), (3) stand tending (early and late non-commercial thinning), (4) black cottonwood regeneration at various spacings, and (5) stocking standard species at even spacing but at lower than normal densities, with spot herbicide treatment. These suggestions are the basis for research currently proposed which, if successful, could result in an economic timber crop and near-natural amounts of grizzly bear forage available throughout the rotation. In combination with a system of long-term deferrals, habitat corridors and critical habitat buffers, these approaches could provide opportunities for reducing conflict and promoting integration. These and other recommendations for the integration of grizzly bears and all aspects of forest management will be compiled in a handbook for use by foresters, engineers, silviculturists, and wildlife and habitat biologists and technicians.

At present, any recommendations on the integration of grizzly bears and silviculture are just that—recommendations. Proposed techniques for the maintenance of grizzly bear forage after logging have been received by the Ministry of Forests and timber industry on an ad hoc basis only (A.N. Hamilton personal communication: 1991). They appear difficult to implement because they are contrary to current Ministry of Forests' silviculture regulations that state that all logged sites must be restocked at prescribed standards and managed until seedlings reach the free-to-grow stage (Hamilton et al. in press). The threat of such intensive silviculture is not so much that the ''ideal plantation'' will be achieved in every stand in every watershed, but rather that such a goal exists without recognition of the implications to wildlife and wildlife habitat. This fundamental philosophy must change before any ''design specifications'' for the integration of grizzly bears and silviculture will work.

Case Study IV: Meeting Demands by Marten (*Martes americana*) for Coarse Woody Debris

In addition to their inherent ecological value, marten are the mainstay of the British Columbia trapping industry. Harvests reach as high as 40,000 annually and are worth over $3 million as raw fur. Most of this harvest occurs in the Sub-boreal Spruce Biogeoclimatic Zone in the central interior of the province. This zone is also important for timber production, and extensive clearcut logging occurs annually through the area. Marten are traditionally associated with mature coniferous forests (Strickland and Douglas 1987). Thus, timber harvest and the associated silvicultural regimes can have potentially serious implications for species because they destroy or modify forest attributes required by marten.

Winter is the critical season for marten. Mobility is restricted, and successful foraging appears critically dependent on access to subnivean prey. This access may be provided by downed and leaning logs, decayed stumps, and large-diameter trees (Clark and Campbell 1977, Hargis and McCullough 1984, Steventon and Major 1982). Spencer et al. (1983) showed that marten prefer foraging sites typified by large volumes of coarse, woody debris and numerous stumps and snags. Also in winter, thermoregulatory costs are highest, and marten require well-insulated dens for resting (Raine 1983, Hargis and McCullough 1984, Buskirk et al. 1988). Dens are almost always subnivean and typically associated with coarse woody debris (Buskirk 1984, Buskirk et al. 1989, Mech and Rogers 1977, Spencer 1987, Steventon and Major 1982). In spring, above-ground dens, often in snags may be necessary to protect kits from wet ground conditions (Wynne and Sherburne 1984).

Because of these habitat requirements, marten do not significantly use clearcuts for up to 15–40 years after clearcutting (Clark and Campbell 1977, Soutiere 1979, Snyder and Bissonette 1987, Thompson 1986). Marten prefers forests with 30–80 percent coniferous canopy and generally avoid areas with little or no canopy cover (Koehler et al. 1975, Spencer et al. 1983, Buskirk 1984). Also, they seldom venture more than 330 feet (100 m) into openings (Hargis and McCullough 1984, Simon 1980, Spencer et al. 1983).

The rate and extent that clearcuts recover as suitable habitat depend on ecological site conditions, the pattern of the forest and the silvicultural methods used. In meeting the goal of maintaining suitable winter habitat or minimizing the length of time for cutovers to return to productive habitat conditions, the key is to reconstruct or mimic the structural features of mature or old-growth forests that are required by marten. For example, given the importance of coarse woody debris to marten, it should be kept at levels similar to that undisturbed suitable habitat. In the moist, cool (formerly subalpine fir [*Abies lasiocarpa*]) subzone of the Sub-Boreal Spruce Biogeoclimatic Zone (Pojar and Coates 1984), this specification means at least 1,430 cubic feet per acre (100 m^3/ha) of logs >8 inches (20 cm) in diameter, and 22 square feet acre (5 m^2/ha) basal area of snags (Spencer et al. 1983, E. Lofroth unpublished data). Accordingly, site preparation should leave some coarse woody debris; practices such as windrowing and burning, stump removal and high intensity broadcast burning are detrimental. Due to the limited life span of coarse woody debris, it is advantageous to save as much large material as possible. This practice allows a longer period of time before the new forest must begin to contribute to the formation of coarse woody debris.

As an alternative to clearcutting, partial logging or other selection systems can effectively maintain marten habitat values, at least in the Sub-Boreal Spruce Zone. These systems can allow for retention of canopy cover, coarse woody debris and large trees for denning. In partially cut stands, two possible design specifications would be to retain at least 50 percent of the basal area, i.e., an average of 90 square feet per square (20 m^2/ha); and to maintain no less than 30 percent of the coniferous canopy cover (Lofroth and Steventon in press).

Case Study V: Winter Range for Mountain Caribou (*Rangifer tarandus montanus*) in Managed Stands

Traditionally, managers responsible for managing mountain caribou have recommended protection of old-growth forests that are caribou winter ranges. However, some severe and prolonged conflicts have arisen between habitat managers and forest managers, and as the demand for timber increases, the potential for conflict also increases. Wildlife biologists and foresters have begun to ask whether or not innovative practices could maintain caribou habitat values in managed stands (Stevenson 1990).

A great deal of research has been conducted on habitat requirements of mountain caribou, their seasonal movement patterns and the importance of arboreal lichens as forage in mid- and high-elevation mature forests (e.g., Servheen and Lyon 1989, Simpson and Woods 1985, Stevenson and Hatler 1985). These studies have shown that caribou feed almost exclusively on arboreal lichens in old-growth stands during winter. The lichens, primarily *Alectoria sarmentosa* and *Bryoria* spp., are generally sparse in stands younger than 100–150 yrs. At high elevations, the six- to nine-foot (1.8– 3.0m) snowpack, caribou can feed on arboreal lichens from the lower branches of trees; at low elevations they use arboreal lichens available as litterfall or on windthrown trees. The most important design specifications for mountain caribou winter range, therefore, must include arboreal lichens at all elevations and, at low elevations, continuing supply of lichen-bearing litterfall and sporadic blowdown.

The primary tool for maintaining caribou habitat values as well as forestry values appears to be the use of selection systems rather than clearcutting. Any of a variety of single tree selection or group selection systems may be used, as long as mature, lichen-bearing trees are always present. Partial cutting maintains a continuing, though reduced, supply of forage lichens and a source of lichen propagules to colonize the regenerating trees.

Where young even-aged stands are already present, there may still be opportunities to enhance the potential for lichen production. However, those techniques are likely to be less effective and more expensive than the use of selection systems.

Partial cutting and other special management practices are currently being tested in a cooperative venture whose ultimate goal is to produce integrated solutions to mountain caribou/mature timber management problems (Child et al. 1990). Fortunately, many foresters are now considering alternative silvicultural systems with new interests. In some cases, the need to accommodate other values, such as watershed resources, recreation and aesthetics, is the primary motivation. Sometimes the motivation is silvicultural; on high-elevation sites that are difficult to regenerate after clearcutting, the preservation of the advanced regeneration and moderation of the microclimate by the residual stand may offer advantages.

However, silviculturists have some concerns about partial cutting in spruce (*Picea glauca*)-subalpine fir and cedar-hemlock types. These include undesirable changes in species composition, reduced flexibility in site preparation options, risk of blowdown and spread of root-rot. None of these problems is likely to be insurmountable. Shade-intolerant species can grow on scarified soil in openings in a partial cut. Harvesting prescriptions can be planned to minimize blowdown in partial cuts, just as the size and shape of clearcut blocks is planned to minimize blowdown. Diseased root systems can be excavated after partial cutting, as they sometimes are after clearcutting. The needs for modified methods of harvesting, site preparation and stand tending for caribou habitat should be viewed as challenges, not as barriers.

Discussion

The foregoing case studies describe attempts to manage forest stands for featured species. It is important to recognize, however, that this focus is not intended to ignore the first and most important management goal—maintaining biological diversity. In the ideal management process, the viability of all species has the highest priority, especially those at risk, with this concern extending to protected and managed forests and non-timbered habitats over the entire landscape of the planning area (and in some cases beyond). Then the needs to meet management objectives for featured species are addressed.

How to Measure Success

How can we determine whether or not the design specifications meet the habitat needs of the species in question? From the wildlife perspective, obvious response variables include continued or increased use of a treated area, population stability, or a population increase. For the mule deer example, assessments have revealed that deer use has not significantly declined in treated stands in subsequent winters (Armleder et al. 1989). For the other species, an immediate assessment is not possible, because many years will be required before the stands develop the required characteristics. For example, it will take >25 years for treated Douglas-fir stands to develop the necessary attributes of black-tailed deer winter range. Even then, any animal-based response will not be easy to interpret because the effects of other factors are difficult to control. The difficulty of evaluation because a negative result (no response) can be interpreted in several ways: the habitat was not appropriate; numbers of animals were reduced by other factors acting on the population; winter conditions did not provide an adequate tests; or a combination of these.

From the timber perspective, response variables may also be difficult to assess fully. For mule deer, treatment trials have demonstrated that selective harvesting can be profitable. Silviculturists predict that future harvest will also be profitable; a similar situation may apply to caribou. For black-tailed deer, changes in timber volume compared to standard approaches will be measurable, but logging to create these winter ranges may not be economical on a stand basis. Similarly, special treatment for grizzly bears and marten may not be economical on a stand-specific basis.

Other criteria for assessing the effectiveness of habitat prescriptions also should be considered. For example, perhaps the criteria should consider the value of government agencies of gaining/regaining public trust to achieve integrated forest management, or the value of continued freedom to manage without legislative obstacles. Another criterion could be the change in managers' perception of risk, i. e., are silviculturists more willing to try experimental ways of treating stands, and are wildlife and habitat managers less likely to recommend the most conservative options of deferrals and preservation?

Implementation

Several challenges face successful implementation. One of these is the need to develop policy to support proposed changes in forest management. For example, in the black-tailed deer, winter range creation projects currently proceed only when a forest company, the Ministry of Forests and Ministry of Environment agree to cooperate; no policy exists to oblige winter range creation. The possibility that existing old-growth stands of Douglas-fir could be released for timber harvest in exchange for creating winter range in managed stands provides strong encouragement for cooperation by forest companies, but the opportunities for trade-offs may not always be available. In some watersheds, no old-growth timber is present. In others, deferred stands have assumed another value—as a component of conserving biodiversity—

and so may not be candidates for logging. Notwithstanding the future of currently deferred deer winter ranges, winter range creation policies will be required to help ensure the creation of winter range required to meet deer management objectives.

A second challenge is the need to modify existing standards. In the grizzly bear example, because prescriptions necessary to maintain forage production appear contrary to the current silvicultural regulations, these stocking standings need to be relaxed in some situations. Such changes will affect the allowable timber harvest and so will affect the annual allowable cut for timber supply areas. Consequently, this stand-level issue assumes importance at a strategic planning level. For marten, the need for coarse woody debris has implications for modifying several policies, including those related to clean site practices, ''zero waste tolerances,'' fire protection, pest protection, planting, access and worker safety.

A third challenge is convincing silviculturists that novel practices can be done. The value of trail and demonstration areas has proven to be effective in convincing ''doubting Thomases.'' In the mule deer case study, the winter range study area has also been used successfully to demonstrate how partial logging can occur on critical deer habitat. In the caribou case study, demonstrations and trials are underway in several parts of southeastern British Columbia to test and demonstrate methods of maintaining arboreal lichens and other habitat attributes in managed stands. In the black-tailed deer example, six winter range creation trials have been established throughout the implementation area. These sites provided first-hand experience for the cooperators who logged the sites, as well as providing useful stops for tours of professional foresters and biologists.

A fourth challenge is to provide effective educational sessions and resource materials. In the black-tailed deer example, two sessions of training were conducted, spaced two years apart, targeted at operational foresters and habitat biologists and technicians. The services of an adult educator were contracted to advise on effective techniques for adult learners. The second session was designed specifically to show how to use the comprehensive manual produced as part of the technology transfer part of the research program (Nyberg and Janz (1990). Similarly, training sessions and a field manual were produced for mule deer.

A final challenge is to provide tools to develop techniques that allow managers to incorporate the spatial and temporal aspects of wildlife habitat into operational forestry plans and habitat plans. As shown in this paper, in British Columbia there has been substantial progress in developing silvicultural prescriptions for site-specific (stand-level) habitat management techniques. However, managers have had little help in assessing the how management plans affect habitat supply and the interspersion of seasonal ranges over ''watershed'' (24, 700–49, 400 acres: 10,000–20,000 ha) and landscaped sized areas. Attempts to integrate habitat concerns and silviculture at the stand level are less effective without integrated management at broader levels. In the grizzly bear case study, some steps are being undertaken: improved integrated planning of silviculture, timber harvest and wildlife habitat; improved mapping and inventories of timber, ecological features and wildlife habitat; increased use of common ecological classification of the landscape to structure integrated management prescriptions; and assessing proposed treatments in the context of available grizzly bear habitat in the watershed (Hamilton et al. in press). Additional research is also underway to address this need (Eng et al. 1990).

The Need to Work Cooperatively

Wildlife biologists and foresters must work cooperatively for several reasons. Wildlife agencies have limited budgets, so can affect only small areas of habitat, whereas forest agencies have large budgets and can affect large areas (Thomas 1979). For species such as caribou, special management is required over large areas. For other and possibly all species, management actions should be evaluated in a larger spatial and temporal context, as noted above. Given these circumstances, Thomas (1979) argued that wildlife agencies must work with forest agencies to achieve habitat management objectives. This logic applies in British Columbia as well.

Wildlife habitat managers need silviculturists to apply their creativity and professional expertise to creating stands that have desired habitat attributes as well as (and sometimes instead of) maximum fiber production. There is a need for mutual respect of each others' professional expertise.

Perhaps the most compelling reason for cooperation is that time and options are running out in British Columbia. There is an urgency in the public mind to resolve these and related questions in integrated management, e.g., how can we handle all the other featured species whose habitat requirement needs cannot be met by practices of intensive timber management? Resource managers have two primary choices. One is to continue the slow, costly route of confrontation. Based on the U.S. experience, this route will likely lead to greater political pressure to enact legislation guaranteeing that all aspects of forest management include all concerns of the public. This ''thou shalt'' approach has caused enormous costs and problems in the management of public forest lands in the United States and, although legal and legislative systems differ between the two countries, Canadians should not discount the possibility of something similar happening here. The other choice is to work more cooperatively towards achieving integrated management. This choice will require specialized stand and forest management approaches, it will take time and money, and reduce timber yields in some areas and on some sites. However, in Canada, most forests are publicly owned and, consequently, public agency managers have a responsibility to consider the needs and expectations of all members of the public. Silviculturists and wildlife habitat managers can play roles in facilitating integrated management, if the will and attitude exist.

We see the job of silviculturists as managing forests and all their components, including structural and species diversity. This broad approach should support all forest values, not timber alone. In this paper, we provide examples of how silviculturalists can help meet the needs of some wildlife species within the framework of managing for all components of forest ecosystems.

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New Perspectives in Alaska Forest Management

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Introduction

New Perspectives

Forest management in Alaska, Canada and the continental United States is being challenged by complex, changing public values and issues. Interest in ecosystem conservation, wildlife, fish, recreation, water and non-urban experiences is growing, as is demand for timber, energy and minerals. This interest is particularly focused on public lands (USDA 1990a). This paper describes the Forest Service Alaska response to these changes—part of the USDA Forest Service ''New Perspectives'' emphasis.

An understanding of New Perspectives requires a brief discussion of *what, why* and *how*. The *what* of New Perspectives in Alaska and nationwide is to better design and implement forest land management plans through improved integration of resource protection and sustainable use, to better manage and sustain ecosystems for all their values and parts, and to be more creative and diversified in our communications, ideas and partnerships. The *why* recognizes some issues are constant—multiple use, preservation and decentralized land management—while others, although historic—habitat preservation, the managed landscape and biological diversity—may require new technologies and concepts (Wilcove and Samson 1987). The need for new ideas and approaches in sustainable use and ecosystem protection has been suggested by many (Cairns 1986, Bourgeron 1988), but examples are few (Orme et al. 1989).

Reconciling competing demands for resource use makes the job of the Forest Service resource manager more difficult than is the case within a single purpose agency (Foss 1987). Multiple-use management relies on the establishment of resource use priorities while sustaining all resources and ecosystems. Furthermore, there are fundamental questions of what range of values to incorporate into management of resources on public lands and how to balance this set of recognized interests within an agency (Francis 1987). The *how* then of New Perspectives is leadership, ability to change the organization structure, consultation with vastly different interest groups, and innovative response needed to manage national forests for a broader spectrum of uses and values in a more environmentally sensitive manner.

Organizing for New Perspectives

The Forest Service Alaska Region Ecology Program was established in January 1989 to integrate ecological concepts and practices more effectively into on-the-ground management on lands managed by the Forest Service in Alaska.

While ecosystem integrity is a traditional value of the Forest Service, increased resource use demands on lands in southeastern and southcentral Alaska create greater need for emphasis on the understanding and applying of ecological principles in management.

An interdisciplinary Ecology Program and Steering Committee was established to provide leadership, direction and an integrated perspective in addressing key issues including ecology and New Perspectives. An action plan was approved, relying on Forest Service line officer direction. Committee membership consists of individuals representing line officers, ecology, lands-waters-minerals, wildlife and fisheries, timber management, research, and public affairs. This committee membership ensures ecological, organizational, management, fish and wildlife, and research are considered in addressing New Perspectives.

Apply New Perspectives to Alaska

New Perspectives is a Forest Service call to action to include participation by conservation organizations, timber and logging industry, state and federal resource agencies, and the public. The Tongass National Forest stretches throughout southeast Alaska from the Yakutat forelands on the north to Dixon entrance on the south. It includes nearly 6.9 million ha and contains the majority of Alaska's timber resources. In 1989, the Stikine Area, Tongass National Forest, located in southeast Alaska identified "New Forestry" as an emerging issue during the annual strategic planning session (Franklin 1989). With the subsequent emergence of New Perspectives as a National Forest Service emphasis in 1989, the Ecology Steering Committee and Stikine Area hosted an invitational New Perspectives workshop with representation from conservation groups, timber industry, academic institutions, state and federal agencies, and the British Columbia Ministry of Forests.

Ideas and comments were synergistic at the Petersburg New Perspective Workshop. Foremost was consensus that forests in Alaska, particularly in the southeast, differ from other North American coniferous forests in structure, function and ecology. These forests, extending from coastal southcentral Alaska into British Columbia, are true temperate rainforest. The significant distinguishing characteristic of temperate rainforest is lack of fire (Alaback 1988, Harris 1989). Periodic and widespread disturbance is evident in southeastern Alaska temperate rainforest in small (0.4–1 ha) to large scale (70 ha or less) windthrow patches (Harris 1989). Landscapes in many areas in southeastern Alaska have a high level of natural habitat patchiness as a result of windthrow in contrast to fire influenced large, contiguous coniferous forest in the Pacific Northwest.

Innovative Responses

The Petersburg New Perspectives workshop provided a forum to review current issues and New Perspectives concepts relative to the Etolin Island Implementation

Analysis (USDA Forest Service 1990a). Land-use planning is the major focus in identifying lands for application of New Perspectives.

In 1989, the Stikine Area, an administrative unit of the Tongass National Forest, headquartered in Petersburg, Alaska, began preparation of a Draft Environmental Impact Statement for the Etolin Island timber sale. Etolin Island timber sale, an area of approximately 27,000 ha, was the first sale in southeastern Alaska in the early stages of planning to accommodate consideration of New Perspectives concepts.

A major cornerstone in New Perspectives is the recommended 1990 RPA Program—a long-term strategy for multiple-use on National Forest System lands (USDA Forest Service 1990a). Two high priorities are to enhance wildlife and fisheries resources and to ensure that commodity production is environmentally acceptable. At the onset of planning for Etolin Island, old growth temperate rainforest wildlife habitat was identified by ground inventories and wildlife habitat capability models developed by the Forest Service Alaska Region Wildlife Habitat Relationships program. The wildlife habitats for species of most concern and other sites of high resource sensitivity were removed from consideration prior to harvest until selection and removal. These high value resource lands include habitats along the beach (150 m in width) to provide wildlife corridors and those bordering salmon streams (30 m in width) and estuaries (300 m in width). These provide further protection for wildlife habitats as well as fishery resources and opportunities for recreation.

The composition and structure of old growth temperate rainforest in southeastern Alaska are known to have habitat values important to wildlife (Sidle and Suring 1986). These include forage and cover for many species of wildlife, particularly the Sitka black-tailed deer (*Odocoileus hemonius sitkensis*). The structure of old growth forest is thought especially important in winter when the old growth canopy intercepts snow allowing wildlife to forage on the forest floor. Harvest of timber can be designed to be more ecologically sensitive habitat for wildlife. A key concept in New Perspective and in timber harvest on Etolin Island is to more closely emulate natural forest succession at the stand and landscape level.

Stand Level

Young forests that follow harvest by clearcutting, the preferred method of timber harvest in southeastern Alaska, lack the structure and composition characteristic of old growth temperate rainforest. Young forest stands are dense, and lack of light penetration slows the development of an understory and plants of the forest floor. About 4,000 ha of young growth forest have been treated over the last decade on the Tongass National Forest by precommercial thinning and creation of canopy gaps. Treatment of young forests to improve habitat for wildlife is difficult given the lack of an industry that utilizes smaller trees. A more effective approach to maintain habitats for some wildlife in areas designated for timber harvest is at initial entry. Three approaches are recommended—gap development, green tree management and securing the edge.

Gaps. One component of New Perspectives is a broad view of harvest techniques to better achieve resource objectives in a more ecologically sensitive manner. Small gaps 0.4–1.0 ha in size are common in southeast temperate rainforest—a pattern of low impact but high frequency disturbance caused by windthrow. A group selection harvest, ranging from 0.4–1.2 ha in size, using helicopter logging will be used on selected sites on Etolin Island to more closely emulate natural forest dynamics and windthrow ecology. Sites include those of high value to wildlife or important to the visual quality of the forest.

Green trees. Green tree management retains small groups of windfirm old trees within or extending into a clearcut (Franklin 1989). These small inclusions provide structural diversity important to animals and plants through the rotation (Figure 1). Specifically, retention of old, windfirm trees provides for a two-layered forest canopy, snags in later stages of forest development, sources of down and dead material, and openings in the developing, dense forest stands. Openings in the forest canopy permit light penetration—a significant influence in the development, distribution and abundance of understory plants. Small groups of young trees provide a third layer to the developing forest canopy, and, over time, variation in age class—a key characteristic of old growth temperate rainforest in southeastern Alaska.

Securing the edge. With most natural catastrophic events, such as fire or windthrow, certain features, often referred to as legacies, survive the event. Legacies include large windfirm trees, snags and small green trees in the understory (Franklin 1989). Feathering a forest edge selectively harvests along the unit boundary to retain legacies, thus secure the newly created forest edge from the impact of large scale windthrow (Figure 1). Channeling wind above the forest canopy by feathering avoids exposing an abrupt border of a harvest unit to wind. Stabilization of unit boundaries is significant to long term forest planning whether for commodity production, wildlife habitat, or recreation, particularly in areas with known or predicted susceptibility to large scale windthrow.

Figure 1. Stand level treatments—the retention within or extending into a harvest unit—to increase structural diversity

Landscape Level

Perhaps the most common approach to harvest timber in North America is to place units across a landscape that results in a regular pattern of clearcuts and equal sized leave strips among units. This harvest design creates edge habitats beneficial to many game birds and big game species, especially for those in fire-regime forests.

Many other wildlife require large uniform habitat and are negatively affected by smaller forest disturbances or forest fragmentation, an issue raised by Aldo Leopold (Leopold 1933) in his 1930 North American Game Policy—and supported in recent research (e.g., Temple 1983, Wilcove 1985). Most notable among the group of habitat size dependent species are the neotropical migrant forest nesting songbirds (Robbins et al. 1989). The long term viability of such species as well as others are thought to be negatively affected by the staggered setting timber harvest (Thomas et al. 1990).

Several wildlife species in southeastern Alaska appear to be sensitive to forest fragmentation and many require minimum patch sizes to prevent habitat capability declines. They include the sitka black-tailed deer, brown bear (*Ursus arctos*) and marten (*Martes americana*) (USDA Forest Service 1990c). Several other species in southeastern Alaska are reported to be either sensitive to fragmentation (e.g., sharp-shinned hawk [*Accipiter striatus*] and blue grouse [*Dendragapus obscurus*]) or were rarely detected along edge habitats (e.g., brown creeper [*Certhia americana*], golden-crowned kinglet [*Regulus satrapa*] and Townsend's warbler [*Dendroica townsendi*]) in other areas of the United States (Rosenberg and Raphael 1986).

A second criticism of the staggered setting or fragmentation approach is the loss of large, continuous stands of old growth forest. Large, continuous stands of old growth are thought necessary to sustain the ecological processes and character of old growth forests. Fragmentation exacerbates the negative influence of edge—an influence that extends two to three tree heights into the forest interior and impacts the forest interior through changes in wind, moisture and light regimes (Harris 1984). Simulation models demonstrate that when as little as 50 percent of the old growth in a watershed has been harvested, little of any forest old growth habitat remains usable by wildlife (Franklin and Foreman 1987). Several landscape models further suggest that forest area is a significant influence on the ecological processes needed to ensure long term persistence (Diamond 1958, Shugart 1984).

Three concepts in landscape management are incorporated on Etolin Island to not only harvest trees but to provide habitats for size-dependent species, ensure ecosystem sustainability, yet maintain a greater range of options for future resource management. They are aggregated harvest, progressive harvest and watershed entry.

Aggregated settings. The aggregation of harvest units coalesces several smaller harvest units (4–10 ha) into one or more larger units. The approach minimizes forest fragmentation by concentrating harvest activities and maintains large continuous stands of old growth temperate rainforest for an extended period in the rotation—this despite a continual reduction in area with each subsequent entry. Second, aggregating harvest units curtail the extent of edge habitat, thus vulnerability to windthrow (Harris 1989) and potential loss of wildlife habitats and timber resources.

An example of aggregating harvest is on the south shore of Anita Bay, Etolin Island. Three large harvest units—10, 21, and 36 ha—were designed in the Landscape Alternative (Figure 2D) by aggregating eight smaller units that averaged 10 ha in size staggered across the forest in the other alternatives (Figure 2A–C). The aggregated harvest provides an 344 ha contiguous stand of old growth forest that, under the staggered setting harvest method in the other three alternatives, results in an assemblage of patches differing in size from 40–140 ha (Figure 2A–C).

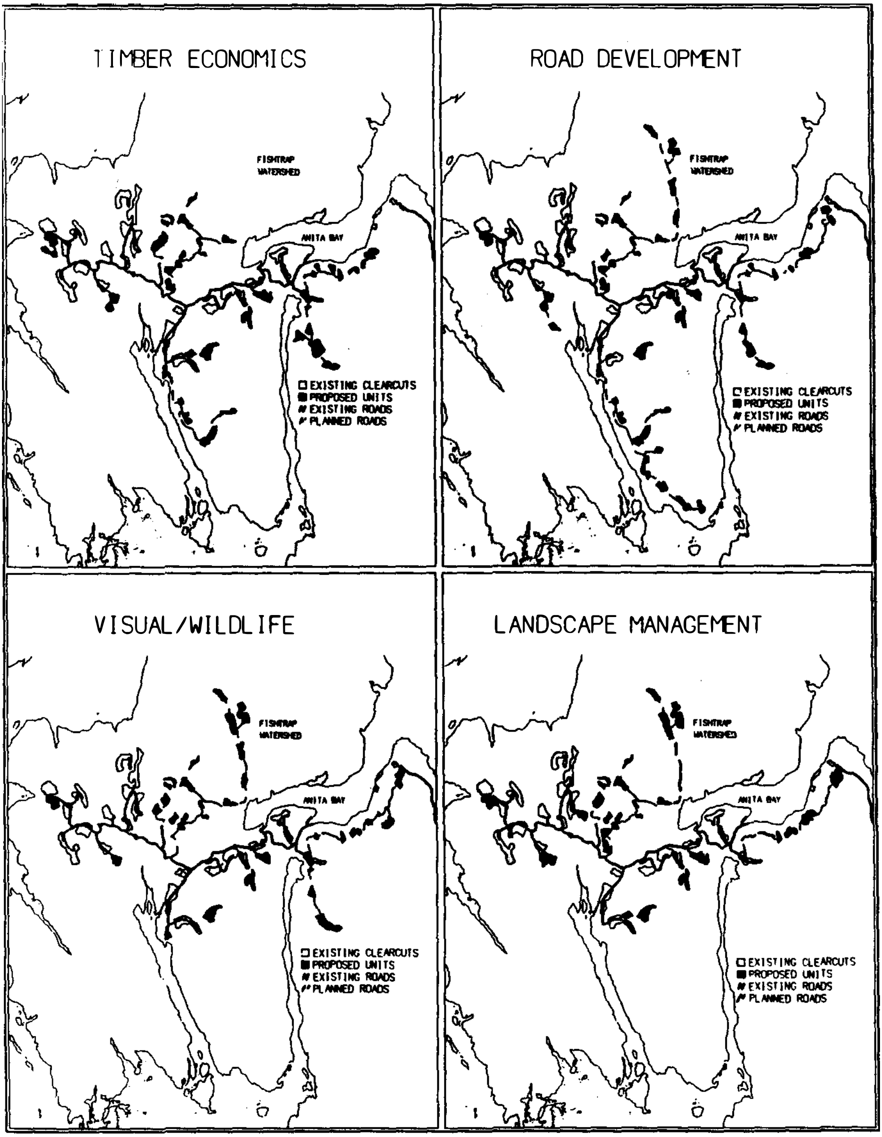

Figure 2. Four management alternatives for the Etolin Island timber sale.

Progressive harvest. Placement of planned harvest units near those previously harvested serves to reduce the extent of edge and increase at any point in time the amount of continuous old growth forest. Four harvest units in the Landscape Alternative (Figure 2D) are planned west of Anita Bay in comparison to three in the Timber (Figure 2B) and Visual-Wildlife (Figure 2C) alternatives. The effect of progressive harvest in the Landscape Alternative is to lesson edge habitat 3–14 percent and avoid entry in nine watersheds (Table 1).

Watershed entry. The initial entry to harvest timber in a watershed permits placement of units to meet needs of multiple use, yet be consistent with current concepts in conservation biology and ecosystem management.

Low quality wildlife habitat is most often found in the upper region of watersheds in southcentral and southeastern Alaska (Samson et al. 1989). Furthermore, Harris (1989) recommends harvesting timber into the prevailing wind direction, southeast to northwest, to lesson windthrow and loss of wildlife habitat and timber resources. Planning in the Landscape Alternative for harvest in the Fish Trap watershed, Etolin Island, considers watershed entry. The design (Figure 2D) locates harvest in low quality wildlife habitat, lessons the likelihood of windthrow and retains a large (385 ha) old-growth stand of low elevation wildlife habitat.

Comparison of Alternatives and New Perspectives

New Perspectives is a commitment to land management based on ecological principles. It is an approach that views not only management at the stand level but considers both landscape and regional ecosystems in the application of new and old management practices.

Implementing New Perspectives through the Forest Planning process is based on development of alternatives that provide a range of resources to include timber,

Table 1. Alternatives for the Etolin Island timber sale. Unit is an area to be harvested, patch refers to forest openings created by management.

	Timber economics	Road development	Visual/ wildlife	Landscape management
Timber produced	47			
(million board feet)		52	44	45
Road construction (km)	41.4	56.6	43.8	40.5
Timber harvest				
Area (ha)	702	778	653	671
Units (No.)	41	44	36	31
Unit size (X, ha)	17.1	17.7	18.1	21.6
Patch size (X, ha)	22.2	22.0	23.9	27.9
Patch perimeter (km)	159	165	149	145
Old-growth stands				
Number	68	72	62	53
Size (X, ha)	22.2	22.0	23.6	27.9
Patches (No. >400 ha)	3	1	2	4
Area (ha)	1760	577	1890	2196

wildlife, fisheries and recreation. Development of alternatives for the development of North Etolin Island was an interdisciplinary process involving resource managers representing timber management, recreation, wildlife and fisheries.

Under New Perspectives, the emphasis is on outcome and not output. The outcome focuses on desired future conditions on what we want the forest to look like—and within that, outputs are produced. The outcome of four alternatives for development of North Etolin Island, each with a different focus, are summarized in Table 1. In each alternative, the planned level of timber harvest as identified in the Tongass Land Management Plan (USDA 1979) is available to local, national and Pacific Rim markets. What is evident are several advantages from a New Perspective view in the Landscape Alternative. Specifically, the Landscape Alternative maintains more large patches of old growth of a 400 ha or more, minimizes edge—thus loss of wildlife habitat and timber to windthrow, and requires less investment in road construction. Importantly, the Landscape Alternative avoids entry in nine watersheds, a marked contrast to the Road Alternative wherein each watershed is entered.

Discussion

Relative to the entire Tongass National Forest, North Etolin Island is a little nore than a postage stamp in a football field. The temperate rainforest on Etolin Island and the Tongass National Forest is one of the unique ecosystems worldwide. The temperate rainforest in the northwestern U.S. is about 2 percent of the area occupied by the tropical rainforest worldwide—a major issue in conservation worldwide, the temperate rainforest supports a unique assemblage of taxa, varying from the Alexander Achipelago wolf (*Canis lupus ligoni*) to the Glacier Bay watershrew (*Sorex palustris alaskanus*).

The Tongass National Forest is developing innovative approaches in land management to ensure the future of all species and ecosystems, and genetic resources of the temperate rainforest. The approach is to establish ecological provinces based on similarities in distribution of animals and plants and ecological processes. Within this province framework are wilderness areas, Research Natural Areas that protect rare plant and animal communities, unique geological features, and rare fossil deposits, management of threatened, endangered and sensitive species, and an approach for maintenance of habitats needed to provide for well distributed viable populations. These are a bottom line for the conservation of biological diversity.

Worldwide protected areas, e.g., parks, refuges and nature preserves, currently constitute less than 3 percent of the world's surface. This percent will not change substantially and is not enough to sustain all worldwide species and ecosystems. Multiple-use lands—those managed for timber, grazing, other resources—will play a key role in conservation of biological diversity. Multiple use is a viable conservation strategy. Developing nations must use their forests as part of conserving them. Management of multiple-use lands as noted before is complex. It has been long recognized that conservation of biodiversity requires a "top-down" approach (Samson and Knopf 1982) and conceptual rhetoric on approaches is commonplace. The long term success, however, in the conservation of biodiversity will rest with tools clearly applicable on the ground and, importantly, developed through an interdisciplinary process and in accordance with national legislation, including the National Environmental Policy Act of 1969. We suggest the stand and landscape level approaches described in this paper are successful on the ground approaches to conserve biodiversity and still produce products for humans.

Summary

Past and present coalesce in the *why* of New Perspectives. Wright et al. (1932) wrote that geographic aspects such as size of habitat, competition with man's activities and historical factors were keys to wildlife conservation. These issues remain driving forces in today's conservation of natural resources. *What* in New Perspectives is to recognize these and other old issues as well as new challenges—such as interdisciplinary planning, public participation and managing for biodiversity.

On the Stikine Area of the Tongass National Forest, the Etolin Implementation Analysis was the first timber sale in the Alaska Region of the Forest Service in early stages of planning to facilitate integration of selected new Perspectives concepts. National Forest System lands in Alaska are a national resource. Many citizens will never view Alaska, yet they share a commitment to conservation of Alaska's natural resources. We suggest the *how* of New Perspectives presented in this paper—a Regional Ecology Program and Steering Committee, application of new technologies and concepts to protect all values of forests while meeting demands for natural resource products, and involvement of diverse and often competing groups—is an effective approach in multiple-use, sustained-yield of natural resources in Alaska. We further suggest that this approach will be of value to other state, provincial and natural resource management agencies to meet changing public demands and values.

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The North American Wildlife and Natural Resources Conference Program Committee salutes **Laurence R. Jahn,** who retired as president of the Wildlife Management Institute on June 30, 1991. Dr. Jahn joined WMI in 1959, serving as its Northcentral field representative. He became WMI's director of conservation in 1970, vice-president in 1971, and president in 1987. He also served as chairman of the North American Wildlife and Natural Resources Conference Program Committee from 1972–1988.

Congratulations, Larry, on a distinguished and productive career with WMI, and best wishes for your continued work for improved management of wild living resources, including soil organisms.