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Opening Remarks

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

Good morning, ladies and gentlemen. Welcome to the 44th North American Wildlife and Natural Resources Conference,

This marks the third time the Conference has been held in Canada; the first was in the same city in 1942; the second was in Montreal in 1955. Out-of-country travel policies and restrictive budgets notwithstanding, I hope that future Conferences can be convened more frequently in Canada and, I may add, in Mexico as well. The Conference is a convenient vehicle for continuing efforts to strengthen fish and wildlife programs throughout North America.

While the three North American societies may have differences in philosophies, policies, procedures and priorities, we share many of the same conservation concerns. Basically, these are concerns brought on by increasing human populations and the effects that human activities have on fish, wildlife, and other natural resources and values.

Examination of the Conference program makes this clear. Although they may differ in time and scale, the parallels are evident: water resources and hydro development; migratory birds and mammals; energy exploration, development and transport; the life styles, claims, and fish and wildlife harvests of native people: behavior of hunters; trapping; marine mammals; wilderness; parks; wildlife administration and enforcement; achieving multiple benefits from forest management; and all the rest.

A major purpose of this Conference is to assist in identifying issues, arranging for their discussion by knowledgeable persons, providing opportunities for additional comments and questions from the floor, and in general, seeking to expand the understanding of interested parties. Some issues will be addressed in national terms, as well they should. Others—such as water and migratory wildlife—require broader treatment, because they cannot be separated neatly by lines on maps.

For those who may not be familiar with this annual meeting, I wish to point out that it is a Conference, not a convention. Attendees are here for the exchange of ideas and information this assembly makes possible. Few are here as instructed delegates committed by any specific policies. For this reason, the Conference does not entertain resolutions or motions of any kind.

Inasmuch as it is customary to refrain from commenting critically on issues within one's country from an outside vantage point—even so close as Toronto—I will not single out pressing domestic conservation issues in the U.S. Instead, I will touch briefly on a few subjects that have the potential of working to the disadvantage of improved natural resources management in Canada, Mexico and the U.S.

Currently in circulation is a second revised draft of a proposed Convention of the Conservation of Migratory Species of Wild Animals, submitted to national governments by the Federal Republic of Germany. It arises from an action plan recommendation of the 1972 Stockholm Conference on the Human Environment. The Federal Republic of Germany is pressing for an international conference in Bonn early this summer, for the stated purpose of adopting the Convention.

This draft Convention confronts the North American wildlife profession with a dilemma. Certainly, there is no objection to encouraging and assisting nations and other units of government to protect and maintain both resident and migratory fish and wildlife. This approach has been available for years through various assistance and exchange programs.

However, the draft Convention raises serious questions about the costs of such encouragement and assistance in terms of disruption of long-established relationships among levels of government in any one country, such as among federal and provincial levels in Canada and among federal and state levels in the U.S. There is uncertainty, too, about the integration of such new authority with carefully drafted agreements such as already exist for migratory birds involving Canada, Mexico, the U.S., Russia and Japan.

It may be that a Convention can be drafted that, in effect, would give certain nations an outside push to do things that they have not been able to initiate on their own, while at the same time, avoiding trespass on established domestic policy and practice. Such opportunities and options should be evaluated by individuals having knowledge of the evolution of North American fish and wildlife policies and programs, who are experienced in their implementation, and who are aware of the social, economic, ecological and other factors attendant their development.

Questions are being raised in the U.S. about the draft Convention, its definitions, framework and suggested procedures. There has not been adequate involvement—at least in the U.S.—of those having legal authority and responsibility for many fish and wildlife species that conceivably could be blanketed under the draft's definition of migratory animals. There is serious concern about the rapidity with which the proposal is being advanced.

I expect there soon will be calls for general examination and discussion of the proposal, including oversight hearings by Congress. There is strong feeling that the U.S. delegation to such a conference should be carefully instructed. Too often in the past, international agreements have been built entirely from the top down. A substantial body of opinion holds that agreements should be built from the ground up.

On a smaller, but no less important scale, questions also are being raised about the proposed agreement among Canada and the U.S. on caribou. Again, care should be taken to build on existing knowledge and strengths, with direct participation of those who long have been responsible for protecting and maintaining the caribou.

Similar discussions are required to resolve the warmly debated Garrison Diversion project in North Dakota. Physical manipulation of the landscape must be planned more sensitively, including to maintain water quality, in both the U.S. and Canada. A better blending of engineering with ecological considerations is needed.

A final concern is the substantial atmosphere of adversity that prevails today within the conservation-environmental movement, among those who purport to be working toward similar goals as well as with other interests. The farther one gets from the core of scientific and professional societies, the more one finds the likelihood of misinterpretation of factual information. Environmental threats that are envisioned and relationships that are suggested sometimes exceed rational expectations.

In an important publication, prominent scientists recently expressed dissatisfaction with some groups by name and suggested that "some of the environmental lobbies are in the business to peddle paranoia."

Paralleling this situation, and perhaps partly because of it, there is a growing demand in the U.S. for stricter disclosure of grass roots lobbying. This is the kind of lobbying where an organization urges its members to voice specific points of view directly to legislators and others. Should this effort succeed to the degree some proponents recommend, a significant roadblock will be placed in the way of delivering public opinion to legislative and policy levels of government. Other signs of an emerging anti-environmental mood are the attacks on several important environmental programs, such as for water and air, and on the Endangered Species Act, and the outright ambush of a proposal for a new and needed national nongame wildlife program in the U.S. Congress last year.

Respected national polls reveal that the public strongly desires and is willing to pay for a decent environment, despite worry about inflation, taxes and energy. This support will remain a dominant factor in resisting Proposition 18-type attacks on the conservation-environmental movement only so long as the public has confidence in what the movement's leaders recommend.

Wildlife Conservation in Canada at the National Level

Honourable Len Marchand[1]
Minister of the Environment, Ottawa, Ontario

Wildlife conservation in Canda is conducted by both the provincial and federal governments. Our national conservation effort is therefore the sum of those activities that are done by the provinces, by the federal government, and by the federal and provincial governments working in close cooperation. In some areas, federal involvement is essential. I think particularly of the conservation of wildlife resources which cross Canada's borders; or wildlife issues elsewhere in the world with which Canada becomes involved as a nation. In other areas, the wildlife resources are primarily the responsibility of the provinces, but some federal involvement is often useful. Caribou herds that cross provincial and territorial borders must be managed by several provinces and territories acting collectively, but a federal involvement is often requested in order to keep the broader national interest in mind. Equally, there are phenomena affecting wildlife which ignore man-made boundaries. An example is the airborne movement of pollutants and toxic substances. Again, federal intervention is often useful and effective in the context of a national conservation effort.

Thirdly, there are topics where cooperation between Canadian jurisdictions is essential, even though the wildlife in question may not cross provincial borders, nor may the factors affecting them. The most recent collective project of this sort is a national Committee on the Status of Endangered Wildlife in Canada. The provinces and territories and the federal government are all represented; so are the museums and the major wildlife organizations. The purpose of the Committee is to determine collectively to what degree individual species or habitats are endangered in Canada at the national level, not at the provincial level.

Another example is the national conservation effort on polar bears. While there is some movement of polar bears across jurisdictional borders, the major conservation issue is to understand collectively the ecology of the various polar bear populations in Canada—and to develop management plans within each jurisdiction which form a coherent whole.

The most familiar example of shared American and Canadian interests in wildlife conservation has been the attention paid over the last 30 years or so to the ducks of the prairies and the Arctic-nesting geese. Together they make up the great majority of the migratory game birds which are bred in Canada but which are shot in the U.S.A. in far greater numbers than in Canada. The Canadian Wildlife Service in my Department, in consultation with the provincial and territorial wildlife agencies, will soon complete its work on a national waterfowl management plan, the most detailed plan that we have yet attempted. The plan has three chief objectives:

1. to review the present status of all the 37 species of swans, geese and ducks breeding regularly in Canada;

[1]Mr. Marchand's speech was delivered by the Honourable J. Blair Seaborn, Deputy Minister, Environment Canada.

2. to define in quantitative terms who in Canada is using those birds, for food or for recreation—for viewing, as well as for hunting; and
3. to identify what needs to be done to reduce hazards to those stocks that may be in difficulty.

The evidence we have assembled upsets some traditional beliefs: it shows that the majority of Canadians derive their enjoyment of waterfowl from birds raised away from the grasslands and marshlands of the prairie provinces. This majority therefore is relatively unaffected by the consequences of further decreases in prairie ducks, whether due to habitat destruction or to over-hunting. We have, for example, to be particularly concerned about what happens here in southern Ontario, where human population pressures are far greater than in the prairies and where the transformation of the landscape has been going on for far longer.

The development of the waterfowl hunter and harvest surveys became possible with the introduction in 1966 of the Migratory Game Bird Hunting Permit. This has given us the most cost-effective and most reliable large-scale surveys anywhere in the world. The use of these surveys is still in its infancy. We are just learning how to relate the distribution of hunting effort to the distribution of the people who hunt and to the whereabouts of the quarry species. The extent to which governments should or can intervene in the matching of supply and demand is not solely a matter of political principle or social policy. It must also be based on sound understanding of the continual ebb and flow of waterfowl populations in response to changing circumstances in all parts of their range. That is why federal and international views are needed, as well as local ones.

We have neglected other important aspects of waterfowl use. We know far too little about the importance of waterfowl to our indigenous peoples or about the recreational pleasure derived by people who do not need to hunt ducks in order to appreciate their presence. The Canadian waterfowl management plan will not only give new direction and purpose to the study and management of waterfowl in Canada. It will also provide at least half of the basic material for the North American waterfowl management plan which Mr. Andrus and I have asked the U.S. Fish and Wildlife Service and the Canadian Wildlife Service to develop.

That will be a big and an important job. Yet having received a possibly disproportionate share of our attention during the last 30 years, waterfowl are going to have to be managed with less effort in future. We must give more attention to the many other migratory birds which are being affected by the continuing human transformation of large parts of North America. In the prairies and parklands, for example, there has been much concern about the destruction of wetlands by modern agricultural practices; but the aquatic habitats have been and are being affected much less than are the uplands. The ploughing up of all but tiny remnants of the native grasslands, the development of vast monocultures, maintained by herbicides, with all sorts of complicated side effects—these must surely have greatly affected the kinds and numbers of the sparrows, the hawks and the owls to be found in the former grasslands or, further east, in the former deciduous hardwood forests. We have to improve our historical and biological understanding of the continent's changing avifauna, not just from curiosity, but so as to enable us to spot the effects of human activities on all sorts of birds early enough to be able to take remedial measures.

Migratory birds which cross the U.S.–Canada border have been managed cooperatively by the two countries since 1916. The original reason for such cooperation was a series of clear threats to migratory bird populations. But what about other species? Until recently, the movement of migratory caribou across the Alaska–Yukon border was not much threatened. The Porcupine caribou herd happened to occupy an area not greatly disturbed by white civilization in either country. Now it is clear that there are threats to the continued existence of that shared herd, and therefore also to the way of life of the Native communities who depend on it. I am pleased to report that Canada and the United States are now well advanced in drafting a migratory caribou convention. This convention would set up a joint commission which would make recommendations to both countries on regulating the hunting of caribou and on the management of the caribou range. We need a continuing joint structure because this stock of animals is now exploited at close to its sustainable level. At the same time it is threatened with industrial disturbance, for example, by the activity associated with the Dempster Highway. It is likely that the implementation in Canada of the caribou commission's recommendations would be in the hands of the territorial wildlife agencies and the Native communities and organizations.

In central and eastern Canada, there are other migratory caribou. Some of these herds cross provincial and territorial boundaries and are the subject of national attention. For example, the Kaminuriak herd which summers in the Keewatin and whose winter range extends into northern Manitoba and parts of adjacent Saskatchewan, is of particular concern at the moment. Its numbers have dropped alarmingly in the past 20 years, and at the present rate of decline it will have vanished in another 10. A major collective effort is now under way by the wildlife agencies of the Northwest Territories, Manitoba and Saskatchewan, with assistance from the Canadian Wildlife Service and the Department of Indian and Northern Affairs. A major factor in the present decline seems to be the number of animals killed for food each year. Communities of hunters, isolated from each other by hundreds of miles, have difficulty in recognizing the relationship of their kill to the welfare of the herd as a whole.

The present crisis in the conservation of the Kaminuriak caribou herd is a clear example of the necessity of collective and cooperative action if wildlife conservation is to succeed. What an individual community or an individual province or territory does can have major consequences on the usefulness of the resource in other places. We must manage such problems in the comprehensive manner of ecologists, and with the participation of all the political units that can affect the ecosystem in question.

Another major caribou herd that crosses a border, and is needed for food on both sides, is the George River herd. Both Quebec and Newfoundland are involved. Neither can manage the herd singlehanded. At present, fortunately, the herd is prospering. Perhaps this is an ideal moment to establish a cooperative management scheme.

Let me turn now to factors which affect wildlife and that either spread across boundaries, or are so extensive that evaluating them requires a national-level effort. Some large-scale industrial activities that are still in the experimental or pilot stage could have important environmental consequences. We in Canada are especially interested in the intensive management of relatively quick-growing trees such as poplars for harvesting as feed stock for liquid fuel or other energy uses. This could change large tracts of country in ways which would affect the abundance and production of ungulates, grouse and songbirds. The effects would not necessarily be detrimental; but there is a need for wildlife managers and biologists to get involved in the design stage of these programs. This would ensure that wildlife and users of wildlife secure the greatest benefits consistent with the primary objective of the industry. I understand that in the U.S.A. the Southeast is the most promising area for such development. Though the tree species are different and their rates of growth much higher than those to be expected in Canada's high latitudes, the associated principles of wildlife management may well be the same.

Moving from the forests to the oceans, we have to be concerned about the effects on marine birds and mammals of the great and growing efforts being devoted to exploitation of the continental shelf. During the rest of this century, the search for and extraction of hydrocarbons will be a dominant use of nonrenewable resources. It seems likely that mining of the seabed for metals will also become a major industry with potential for environmental damage by the scattering of toxic materials. The hazards of offshore drilling for oil and of marine oil transport are already well known, and I am acutely aware that off Canada's east coast the troubles are still in their infancy. Drilling in deep water that is ice-covered or iceberg-infested is surely one of the most dangerous of all industrial activities. The seabirds of Lancaster Sound, Davis Strait and the Labrador Sea are at great risk and we know that if massive die-offs occur from oil pollution, the recovery time will be many decades, if not centuries.

The marine animals are also at risk from the expansion of fisheries, particularly now that, following the depletion of the stocks of many of the preferred food fish, attention is being turned to the capture of large tonnages of capelin. This is a principal food of many birds and mammals, as well as of the larger predatory fish.

Massive losses of marine birds in Canadian waters, whether from oil spills or from depletion of their food supplies, are not solely of interest to Canadians. The birds using our waters, especially in winter, are drawn from many regions, including Greenland, Iceland, Spitzbergen, northwestern Russia and the British Isles.

In the broad context of understanding the effects of toxic materials on the environment, wildlife has played a crucial part. Research which showed that wild birds were either directly killed, or had their reproduction impaired, by agricultural or industrial chemicals, was an early warning of more complex and pervasive effects of those chemicals throughout the environment. We in Canada have vigorously pursued this line of study, and we are about to begin a new phase. After looking at direct mortality and reproductive effects, we are now going to look at the effects of pollutants on the chromosomes of wildlife. Since the chemical basis of genetic materials is the same throughout the animal kingdom, results of this research could have wide implications.

While anxiety about the effects of activities on the continental shelf obliges us to consult with several European countries, I believe that other international actions by Canada are even more important. Since we began to take part in the work of the International Waterfowl Research Bureau in 1975, we have become aware of the great reputation of the U.S.A. and Canada as countries in which the management of waterfowl and wetlands is far advanced. While that reputation may not be wholly deserved, it obliges us to play a leading part in advising the developing countries on the preservation of wetlands, both practically and by legislation. A recent meeting of the International Waterfowl Research Bureau in Tunisia demonstrated that Canada is well qualified to help the francophone countries of Africa and elsewhere, because we have a cadre of French-speaking wetland specialists and because our technical publications are in French as well as English.

We are also very much concerned about the environmental changes taking place in the wintering areas of Canadian-breeding birds in the Caribbean and in Central and South America. There is little point in fighting to keep essential breeding habitats in North America unless we are also prepared to help in the maintenance of sufficient staging and wintering areas. Sites essential to shorebirds and to several groups of songbirds seem to be specially at risk. We are still dangerously ignorant of the locations that are most important and of the mechanisms for protective action that may be effective in different countries. In some places, visiting hunters from North America or Europe are encouraged by the tourist industry to behave in ways that would be quite unacceptable in their home countries. We must find ways of cutting these anachronistic "great white hunters" down to size. It is ridiculous for North American hunters to travel to Venezuela, for example, in order to shoot, without legal limits, some of the blue-winged teal breeding in the prairies which we try to conserve by bag and possession limits in Canada and the U.S.A. It might be even worse to divert the attention of reckless visiting hunters to local nonmigratory stocks of birds.

Effective international cooperation in wildlife conservation throughout the Americas will require great patience, persistence and tact. So far, Canada has lagged behind the U.S.A. and Mexico in collaborating with the many other countries involved. We intend to try harder in the immediate future. We look to Mexico for leadership in this region.

One of the important international activities in wildlife conservation to which Canada is contributing is the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), to which Canada became a party in 1975. The greatest needs here relate not so much to animals indigenous to North America as to those found in the developing countries, particularly in the tropics. The international trade in the skins of the spotted cats has imperilled many species. Canada has been far from blameless in this traffic, but I believe that we are now well on the way to controlling, and where necessary eliminating, importation to Canada despite the many technical problems involved.

Taking the widest view of international responsibilities in wildlife conservation, I welcome the publication in September 1978 of the second draft of *A World Conservation Strategy* by the International Union for Conservation of Nature and Natural Resources (IUCN), the United Nations Environment Programme (UNEP) and the World Wildlife Fund (WWF). I am particularly happy that the Director General of IUCN, who will have a big part to play in the implementation of that strategy, is a Canadian and a former member of my Department, Dr. David A. Munro. I can assure him of our support.

Strengthening National and International Wildlife Programs

Honorable Robert L. Herbst
Assistant Secretary for Fish and Wildlife and Parks, U.S. Department of the Interior, Washington, D.C.

It is not often that I have the honor of opening an address with a personal message from the President of the United States. So it is with a deep sense of honor that I read to you the words of President Jimmy Carter, written at the White House on March 20th for this specific occasion:

> Waterfowl are among America's most cherished wildlife resources. The fall flights of ducks, geese and swans do not just represent the passing of a season. They are a priceless international resource and a symbol of nature's proud endurance in a changing world.
>
> We can enjoy this waterfowl resource today because of the continuous efforts of dedicated conservationists such as the participants in this Forty-Fourth North American Wildlife and Natural Resources Conference. Through careful planning and unceasing diligence, you have made great strides to preserve and enhance the living habitats on which our waterfowl depend.
>
> I am pleased to join you on this occasion in expressing special recognition for one group that has been particularly successful in protecting waterfowl. I offer my warmest congratulations to the Migratory Bird Conservation Commission on the occasion of its fiftieth anniversary.
>
> Through the efforts of its members over the past half-century, the Commission has helped create 311 national wildlife refuges in 42 states—over ten million acres of vital habitat to provide breeding grounds, sheltered resting places and safe wintering areas for waterfowl. I share your pride in these accomplishments and wish you all a very stimulating and successful meeting.
>
> [signed]
> Jimmy Carter

My assigned topic this morning is "Strengthening National and International Wildlife Programs," and I intend to deliver as advertised. But before I get to that crowded, intriguing agenda, I want to place the framework of your overall conference theme around my remarks.

"Consolidating Conservation Efforts" has more than a nice ring to it. Nature herself has shown us the thermodynamic case for consolidation in a system where declining energy supplies dictate efficiency. In a very real, measurable way, the curtailment of our energy could turn out to be a conservation blessing. Even though it comes shrouded in a thick, ugly disguise, the signs tell us something good may be lurking behind. There are dangers too—and I will get to those in a minute. They affect natural resource managers in a peculiar way. But for now let me just say that affluence is the gateway to extravagance. Scarcity points in the other direction—toward conservation. And so, while we work as hard as we can to develop new energy sources that will continue to strenghthen our economies, we can also respond to scarcity in a healthy, creative way—by consolidating our efforts to conserve—by joining our minds and muscles as well as our pocketbooks in the creation of a wholesome, various, diverse, efficiently managed resource base.

The fish and wildlife segments of that base represent our lifeline from the past, the strong rope of continuity between the great resources we found laid out for us on this continent and what we have made of them. The work we do here also is part of that rope, and it acknowledges the enormous area of interaction between the worlds we manage and the world we manage *from*. The animals whose continued purchase on this planet depend on what we do will never send us a note of thanks, but a future human population may some day pause and honor the effort to which we contribute at this conference.

Recently I have been involved in a round of "mid-term orals," reviewing the conditions that prevailed when the present Administration took office and the accomplishments of the ensuing two years. The exercise has involved a good many heartfelt "thanks" to groups of likeminded people who have buttressed our determined efforts to turn things around. Nowhere are such thanks more appropriate than to this group. You represent concerned citizens, yes. But you also represent them by the kind of tough, professional expertise that it takes to translate these highminded concerns into nuts-and bolts-progress. You know how to work with governments and with citizens. You have canny lobbyists. You can talk softly and persuasively in the accents of science and technology. And you know how to fashion and wield a battering ram when that is the only language that can carry the day. I am proud to be part of your effort and devoutly grateful for what you provide—not the least of which is this forum for surveying our position and proposing ways of strengthening our collective hand.

Two years ago, such priceless rivers as the Pere Marquette, the Rio Grande, the Skagit, the Delaware, the St. Joe and the Missouri, were unprotected and little action was planned. The New River Gorge, a timeless clue to our evolutionary past, was under increasing development pressures. Power plant sitings, coal leases, outer continental shelf drilling programs, all were being resolved without sufficient consideration for the point of view which all of us here at this meeting represent. Wilderness proposals for places such as the Everglades, Carlsbad Caverns, Hawaii Volcanoes—close to one million acres—languished in one stage or another of the administrative process.

In Alaska there was some question as to how strongly the former Administration would support protection of the national interest lands proposals so painstakingly developed following the passage of the Native Claims Settlement Act. The bulldozers and real estate salesmen were poised, aimed at whatever chinks might show in our armor.

In the past two years we have demonstrated our determination to write a proud record of accomplishment in all these areas where wavering and waffling were the order to the day. We have instituted strong science programs to back our protection of such irreplaceable treasures as the Redwoods, the Carlsbad Caverns, the Everglades, the Indiana Dunes.

The Delaware River now is protected in its upper and middle reaches and Tocks Island Dam and Reservoir will never be allowed to spoil the existing environmental splendor. The rivers that I named before are now protected totally or in part under the Wild and Scenic Rivers Act. The New River Gorge is a National River and will become one of the outstanding features of the National Park System.

The National Park Service is now organized to emphasize the necessary scientific baseline for our decisions. We also passed the Refuge Revenue Sharing Act Amendments, which make all Service lands subject to payments to counties and will provide for greater value equity in the amount of payment made. In carrying out the provisions of the Act, the payment of funds in lieu of taxes will dissolve much opposition to the land acquisition program.

We passed the Migratory Bird Hunting Stamp Act Amendments, which provide for an increase in the price of the Duck Stamp from $5 to $7.50, thus sharply increasing the funds available for the purchase of migratory bird habitat.

We assembled a National Wildlife Refuge Review Task Force to make recommendations for management of the Refuge System. The initial cut had just been made when I addressed the National Wildlife Federation at this same joint meeting last year. An intensive period of public response followed. On September 12, 1978, Fish and Wildlife Service Director Lynn Greenwalt's final recommendations, reflecting his reading of the public comments, reached me. I considered these, along with my own analysis of public comments, and the result is a new policy for the Fish and Wildlife Service of the United States. It is a product of the most informed minds in and out of the Service in the area of refuge management. It embodies directives that issued from the Task Force recommendations and that cover the entire range of refuge activities—from mining incursions (which could interfere with the refuge mission) to environmental education (which could extend and amplify it.) I expect the clearly stated policies to be reflected in the day-to-day management of the National Wildlife Refuge System, and I have so informed its personnel.

Under the leadership of my deputy, Dick Myshak, we now have an Animal Damage Control Policy Study Advisory Committee—created last year to help alleviate the predator impact on livestock from coyotes. The committee is made up of representatives from the livestock industry, conservation organizations, academic institutions and state and federal agencies and they have worked with the U.S. Fish and Wildlife Service in developing a study entitled "Predator Damage in the West: A Study of Coyote Management Alternatives." The study was published last December and we are now in the final stages of an environmental impact statement and secretarial decision process. The Advisory Committee's roles were to validate the use and interpretation of data, help assure that options were properly enunciated, ensure that analysis was technically sound, fair and balanced, and that the study was conducted in an open manner. The policy and management decisions, which will be forthcoming this summer, will be aimed not only at alleviating the predator problem, but equally, if not more so, at protecting the species.

Other initiatives, taken through the Heritage Conservation and Recreation Service, especially those dealing with urban parks and the National Heritage Program, hold important hooks into areas of concern to fish and wildlife managers. A complete re-think of the administration of our Historic Preservation and Archeological Services is slated to take place this year, with a program of reformation set for January 1, 1980. Like geese and caribou, history leaves its marks on our landscape with a fine disregard for political borders. The colorful Klondike gold rush trail and historic sites are now a joint Canada-U.S. exercise in historic preservation. For the first time, we have comprehensive policy planning for preservation in the United States, and again, I think it will be evident how this holistic thinking behind our planning will help them to dovetail with programs of the North American Wildlife and Natural Resources Conference.

Last year I devoted a good deal of my National Wildlife Federation keynote to the plans I had for building a consistent, coherent federal role within a national wildlife policy—one that would in effect "pull together all the good stuff" that is currently in use on this continent and build a beacon to inform and infuse all our federal efforts. I traced the roots of this project from the solid foundations laid in 1930 by Aldo Leopold's Committee on American Game Policy through the 1973 report from the Committee on North American Wildlife Policy sponsored by the Wildlife Management Institute. I am happy to report that one year later we are well on the way and will have a readable, meaningful document on the table for official review and public discussion when the International Association of Fish and Wildlife Agencies meets in September of this year.

I have acquired as my special assistant, Dr. Jay D. Hair, who administers the Fisheries and Wildlife Sciences Program at North Carolina State University. Dr. Hair (who by the way received his doctorate from the University of Alberta in Western Canada) has extensive experience in natural resource legislative and policy matters. He is active in both the academic and the "real" world of biopolitics, and I am delighted to have him working with Director Greenwalt and myself on this important endeavor. What Jay is doing is not being done in a vacuum. Already he has interacted with a number of key people in the Carter Administration and with others who represent the membership of the Natural Resources Council of America. A continuing liaison with these people should produce a meeting of many excellent minds.

At the top of our list of national policy concerns stands the matter of federal and state fish and wildlife authorities. Ultimately, the policy statement will address in a substantial way the authorities and responsibilities of the federal and state agencies. "Clarification without aggravation" is the name of the goal we pursue, and I sincerely believe it to be attainable.

Actual achievement of such a consensus will hinge to a great extent on reorganization at the federal level. Secretary Andrus covered the proposed organization of a Department of Natural Resources (DNR) earlier in this series of meetings at the National Wildlife Federation gathering, so I will simply say that President Carter has proposed using the Department of the Interior as the logical nucleus for such a new department, with all its present functions remaining intact. In addition, the U.S. Forest Service moves from Agriculture to the new department; the National Oceanic and Atmospheric Administration now in Commerce also moves to DNR. The proposal is a banner under which all these agencies can unite.

In close keeping with the theme of this conference—"Consolidating Conservation Efforts"—the objective of the proposed Department of Natural Resources is the coordination and interrelation of all these resource management activities . . . the provision of a single clear voice for public land management. We will be in much better position to see that our land and ocean management complement each other and that they are in phase with our recreation and wildlife programs. Our scientific and data collection functions can be integrated to provide the support and information needed for intelligent decision making. Deep differences in mission and point of view will, of course, not be wiped out by the stroke of a reorganization pen, but many of the minor battles that sop up our monies and energies *can* be dissolved. It is our goal to have the national wildlife policy well-developed and ready to become a federal centerpiece when this tighter, more efficient, more effective organizaiton comes into being.

On June 6, 1978, President Carter sent a message to the federal agencies calling for increased environmental sensitivity in water resources planning and management. One of the important initiatives in the message was that environmental mitigation measures be considered as an integral part of the planning and development of federal water projects—not as a post-project afterthought.

In his January 25 State of the Union message this year, the President spoke of a comprehensive water policy which included many reforms now being implemented administratively, and then he added:

> In addition, I will propose legislation to increase the role of the States in water policy, through increased water planning grants and through new grants for state water conservation programs. I will also propose legislation which would provide for states to share in the costs of Federal water projects. This cost sharing proposal will result in direct participation by states in setting water project priorities and will help ensure that Federal programs are responsive to the most pressing water-related needs.

A major step in the direction of consolidating conservation efforts is the new set of regulations to be announced shortly by Interior Secretary Andrus, requiring all federal agencies to give fish and wildlife conservation equal weight with economic and other benefits in planning water-related projects. These regulations will include discharge and municipal and industrial wastes, hydroelectric power generation, and flood control structures, among others. Secretary Andrus has called them "a major step toward implementing the President's water policy," and in effect these rules, when adopted, will give decision makers a truer picture of the overall impact of water projects on wildlife resources and a better basis for making decisions.

The rule-making amounts to putting teeth that *meet* into an old law—the 1934 Fish and Wildlife Coordination Act. This Act required all federal agencies involved in deepening, diversion, impoundment or other modification of a stream or body of water to consult first with state and federal wildlife agencies. But no formal procedures for this requirement had ever been adopted and the result was that implementation was spotty. Those agencies that *have* complied will find their continuing efforts enhanced when standardized response from *all* agencies gives our water conservation teeth more perfect bite.

Standardized agency procedures will assist project planners in designing environmentally sound projects. The agency that proposed the project will make final determinations as to measures for conserving or compensating for wildlife resources, but the law *mandates* that the views of state and federal wildlife managers be taken into account in making that decision. The regulations also ensure public participation, and that participation is being solicited right now, in the process that is leading to approval of the proposed new rules. The new procedures, specifying consultation on fish and wildlife resources in the beginning—not at the end, where project delays and cancellations are most costly—makes the utmost good sense. These new actions amount to inviting the environment, at long last, to sit at the water policy head table. They should add a powerful new weapon to those of us who fight for balance in the life patterns of Earth.

As you all know, in 1977 the Fish and Wildlife Service initiated a 10-year accelerated habitat acquisition program. Wetlands habitats were classified in 33 categories, with priority given to breeding and wintering habitat . . .most especially in areas of high wildlife value that currently are under near-term threat of destruction. The 10-year goal is to preserve 1.95 million acres (790,000 ha) of wetland habitat, in addition to the 2.3 million (932,000 ha) that is our accumulated treasure from the past 50 years. In the half a century since Congress enacted the Migratory Bird Conservation Act, and set up a commission to study and approve the purchase or lease of sanctuaries, we have spent $250 million setting aside this precious 2.3 million acres.

We do not fool ourselves that the additional 1.95 will have a similar price tag. The cost of "saving the nest that cradles the goose that lays the golden egg" is going to be much higher. But our flyway-associated governments agree on the primacy of this goal, and the stepped-up price of the U.S. Duck Stamp, plus the amendment to the Migratory Bird Conservation Act that allows us to initiate a wetlands easement program, attest to the U.S. commitment to maintaining the flyways populations.

The new national inventory of wetlands, designed in 1974, will provide data on characteristics and extent of the various types of waterfowl habitat on a sound, multiple-use basis. Using satellite imagery and computer mapping, the inventory is progressing rapidly. A new wetland and deep water habitat classification system already has been developed.

The Great Lakes Fishery Commission, established by U.S.-Canadian Treaty in 1955, is another of the success stories that beckons us down the trail to international cooperation. Its four commissioners from each of our countries have committed the Commission to develop a comprehensive fisheries plan for the Lakes. This move constitutes the first significant attempt to identify an orderly management system for each of the Great Lakes, and I am proud to be the vice-chairman of the group that will see this resolve carried out. The successes racked up so far were by no means what the youngsters today would call "a piece of cake." The turnaround was achieved after decades of pollution, over-fishing, changing environments, lamprey predation, and other assorted evils. Today the Lakes provide employment, food, recreation and many other benefits to more than 30 million Americans on our side of the Lakes. I have not seen the figures for Canada, but imagine they tell a similar story.

Still in pursuit of consolidating our conservation efforts, the U.S. and Canada recently completed a joint nomination to the World Heritage List of our two great adjoining natural areas—Wrangel-St. Elias National Monument in the United States and Kluane National Park in Canada. This is the first joint nomination by two countries of a single total ecosystem and it sets a wise precendent for national recognition that nature's boundaries do not necessarily coincide with political boundaries.

Sixty-three years ago, in 1916, the United States and Great Britain (on behalf of Canada) signed "a convention for the protection of migratory birds." This early document laid the groundwork and established the principles for international management of the migratory birds of North America. But birds, like the other components of ecosystems, do not stay put. Their flight plans take no note of international boundaries, so other treaties had to follow. In 1936, the U.S. signed a similar convention with Mexico, amended in 1972. In that same year, the Japanese Convention was inked, and most recently, on October 13, 1978, the U.S. and the Soviet Union formally exchanged instruments of ratification for a convention to protect migratory birds.

The Migratory Bird Treaty Act, which implemented the U.S.-Canadian Convention of 1916, serves as the U.S. umbrella document for implementation of the other migratory bird conventions. The Interior Department is guided by the most restrictive provision of the Migratory Bird Treaty Act text, in order not to violate conditions of any of the treaties. The Soviet Treaty reflects current thinking on the setting of seasons for subsistence uses where there are established nutritional and/or human survival needs. It contains explicit provisions for the setting of subsistence seasons to regulate such use and to assure the preservation and maintenance of stocks and migratory birds.

On January 30, 1979, the U.S. Secretary of the Interior and the Minister of Environment, Canada—Cecil Andrus and Len Marchand—signed a protocol to amend the subsistence hunting provisions of the 1916 Migratory Bird Convention with Canada. The amendment, which makes the subsistence hunting provisions of that treaty consistent with those of the recently ratified treaty with the Soviet Union, will be submitted to the U.S. Senate for review and ratification. The major problem addressed by the amendment is that subsistence hunting of migratory birds, as practiced for generations in Alaska, for the most part is illegal under terms of the 1916 treaty with Canada. This treaty prohibits hunting between March 10 and September 1, the period when waterfowl are most available and most needed for food in the far North. There are exceptions in this treaty for subsistence hunting (by Indians and Eskimos only) outside these dates but they apply only to species (scoters and certain sea birds) that are either not generally available or not traditionally utilized in most northern areas, including Alaska. This makes for major conflict between the limitations in the treaty and the legitimate subsistence needs of people.

The Soviet treaty provides, in essence, that indigenous inhabitants (not just Indians and Eskimos) of Alaska may take migratory birds for their own nutritional and other essential needs (as determined by competent authority) in accordance with seasons and other appropriate regulations set by the competent authority. The seasons must be set so as to provide for the preservation and maintenance of stocks of migratory birds. Thus, there is a clear provision for regulation and control of subsistence hunting (not provided in the original treaty), and for safeguarding breeding populations of birds. The amendment will incorporate these provisions into the Canadian treaty.

Migratory bird treaties with Mexico and Japan will be similarly amended before implementing subsistence hunting provisions. This will be done in accordance with the expressed intent of the Senate that our other migratory bird treaties be made consistent with the Soviet treaty, in regard to subsistence hunting. When the other treaties have been amended and approved by the Senate, the subsistence hunting provisions will be implemented by establishing regulations to control the time, place, extent, and methods of subsistence hunting in Alaska. It is likely that such regulations will not be established before the spring of 1980.

Most of our international travelers wear either feathers or fins, but the largest of our migratory individuals wear fur. Here too, the U.S. and Canada are moving together, as sovereign nations, into a strongly cooperative protective mode. The Porcupine caribou herd, numbering approximately 100,000 animals, migrates between the Yukon and Northwest Territories and Alaska. The principal calving area is in Alaska, primarily within the Arctic National Wildlife Range. They have a wide spring and summer range in adjacent areas of Alaska and Canada, the main wintering area being in Canada. When I met with Assistant Deputy Minister Bruce recently, we agreed in principle to the development of an international convention for the protection and management of the Porcupine caribou herd and its range. We are presently working together on a draft proposal for such international management of the herd. We hope this will serve as a model for international cooperation between the federal agencies, the Territories, and the State of Alaska.

Our two governments are cooperating on the development of research and management guidelines so as to provide adequate protection to these caribou and their habitat, at the same time assuring the subsistence needs of the Natives. Here again the U.S. and Canada are pioneering in cooperative management of a major migratory wildlife resource. The proposed enlargement of the Arctic Wildlife Range will provide increased habitat protection for this spectacular wildlife shuttle. It is a soul-stirring migration and no one who has witnessed it would ever feel comfortable with any action that would tend to interrupt this ancient pattern.

Another hopeful move afoot is the one to cooperate in designation of wild and scenic rivers—called "heritage rivers" in Canada—wherever these rivers cross borders. Such mutual designations of the values of these rivers will contribute in a complementary way to the wisest possible management of the fish and wildlife they attract and support. I understand that Heritage Rivers in the Yukon and Northwest Territory are being studied now with an eye to putting entire rivers under national protection. This is good news on both sides of our borders.

One of the most promising avenues in pursuit of the strengthening of international wildlife programs is the Man and the Biosphere Program (MAB)—outgrowth of the 1968 UNESCO Biosphere Conference. At that time, Dr. Stanley Cain was sitting in the seat I now occupy. He termed the objectives of that first conference as amounting, essentially, to "ecological planning." It was also recognized at that time that sound ecological planning depended on integrated environmental research programs that would have the full participation and support of *governments*, thus adding additional clout and backing of formal national recognition to the ad hoc scientific network already in existence at that time.

In 1970 the outline of the program that became Man and the Biosphere was presented and agreed to at the UNESCO General Conference. So far, the concerted actions called for by Dr. Cain more than a decade ago have not been taken. But the need for them has deepened to the point that if such an organization as Man and the Biosphere had not already been formed, such a movement would have to be undertaken now from scratch. Thank Goodness this is not so. We *have* the program, and it has continued to take shape and stature along with the international needs it fills, awaiting only sufficient funding and technical expert backing from the individual governments to get on with its tasks. Such backing is now forthcoming in the United States. On March 16, a joint memorandum from the Office of Management and Budget and the Office of Science and Technology Policy went to the heads of executive departments and agencies. It stated in part: "The Program provides an excellent opportunity for international cooperation and a focus for the coordination of related domestic programs aimed at improving the management of natural resources and of the environment."

The memorandum gives the Department of State responsibility for developing the international aspects of the Program and gives the Department of Interior and Agriculture joint responsibility for developing the domestic program. The objectives of the MAB program are directly in line with my own and Secretary Andrus' objectives at Interior—to coordinate and integrate the research, resource management, and education efforts of the bureaus. I am calling for financial support from the Fish and Wildlife Service and the National Park Service in their 1981 program strategies. The resulting coordination of effort and improved results will surely reduce cost and duplication of effort, in addition to improving international relations.

The whole great subject of Alaska I will merely allude to. Any attempt to do more would demand another speech of equal length. Secretary Andrus told the National Wildlife Federation meeting of our total commitment to "doing things right the first time" in that vast and incredibly rich land. We are using every tool at our disposal to outwit and outmaneuver those who would repeat all the mistakes of our earlier frontiers, and I can only say to those of you whose land abuts Alaska that we are absolutely determined to keep the highest faith. We will not blot this fresh, new page in our environmental copybook.

It is a fact of life that despite our attempts to control our own future, in most cases the great movements of history are well underway already when we begin to recognize them. Emerson acknowledged this when he said—somewhat ruefully: "Things are in the saddle and ride mankind." The "thing" I want to call attention to here is one we can recognize with joy, not regret. It is the growing synthesis of effort between the fish and wildlife management teams of our two nations, a meshing that is well along. We recognize it because of the eminent good sense it makes. Canada's superb research in both wildlife and fisheries is a worthy standard for our own. Canada's experience and wisdom with regard to preservation of whole ecosystems is a priceless reference point for U.S. efforts in Alaska.

Human perspectives and insights loom large in the international patterns for managing wildlife and wildlands, and nowhere does the human element shine more glowingly than in the person of Ian McTaggert Cowan. You have chosen to honor him here for his singular contributions to world conservation, and that honor would have been more than justified had it been based solely on his personal contributions to the cause. But making him especially precious is his tremendous "amplifier effect," as a teacher, mentor, and creator of continuing stewardship. Ian McTaggert Cowan is a symbol of our growing oneness in continental conservation, a reservoir of wisdom and an inspiration for conservation leaders everywhere. I want to add my voice to the chorus in his praise.

I promised in the beginning that I would touch on the subject of energy and mineral scarcity, and as I wind this up I direct your attention to the challenge it poses to consolidation and efficiency. There is another side to the attractive coin of "challenge," and that side is marked "threat." I have picked up warning notes of this side on Capital Hill in Washington, D.C. I feel that something like the natural resource crunch that faced those whose mission was preservation during World War II may be about to recur, and if it does, we have some good, substantial heroes from the past to help us find our way.

Newton Drury was Director of the National Park Service when the World War II effort was taking its bite, and there were people around who counted—as "national defense"—*only* those things that were being built-into, or burned-in-support-of, the war machine. Drury stood his ground and saved the Park System forests that were being eyed as "essential to the war effort." Since that day, millions who do not know Drury and who were never aware of the forests' close call, have continued to enjoy the fruits of that preservation stand and all the "pleasuring" it has provided. The "future generations" of Drury's day have come, enjoyed, and many of them have passed on, but the threat is back again in the form of energy hunger. It reminds us that conservation wars are never *won*. The best we can get is respite to restore our strength and commitment. The crisis I see mounting is sure to take the full measure of both.

We will be equal to the task only if we inform ourselves and enlist suport from the public by sharing our information freely. An important part of that information is an understanding of the enormous free natural energies that work day and night to undergird all our human enterprises. If we forfeit these longterm energies by disrupting the natural systems that generate them, we will in the end be left with neither the nonrenewable fuels we gouged out, nor the renewable energies we have *canceled* out. There is tremendous need for clarifying this fact, whether by environmental education, by interpretation, by public affairs outreach, or whatever.

As the world's human population struggles toward an eye-level view that will somehow square with the portrait of our indivisible world taken by the first camera in space, it may well be that a little bird—or a national park—will lead us.

Certainly it is nature and its Author that have laid out the ecosystem boundaries and imprinted the migratory patterns into the gene pools of condors and caribou—without regard for our highly-esteemed political boundaries.

As we initial treaty after international treaty in support of the world's migrants, as we join park to park in acknowledgment of the total ecosystem worthy of World Heritage status, we are aware that we are pursuing sanity and reality when we pursue wholeness. The lines that mark our countries' boundaries—the lines that define federal, state and provincial agencies—they are either dividing lines or connecting lines, and therein lies all the difference.

A Strategy for the Conservation of Wild Living Resources

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Conservation is on the brink of massive failure. Paradoxically it also faces opportunities for success that it has never had before. If we are to seize these opportunities, as we must, I believe the conservation movement must change radically in at least three ways: it must operate more effectively at the global level; it must have a much more positive approach to development; and it must work to a common strategy.

Conservation's job is to ensure that the biosphere—and the ecosystems and species that comprise it—can continue to benefit current and future generations of people. It aims to do that by maintaining life-support systems through the conservation of ecosystems, by preserving genetic diversity through preventing the extinction of species and varieties, and by maintaining exploited ecosystems and stocks of plants and animals at sustainable levels.

In all these aims, we are failing dismally. Despite the best efforts of conservationists, and their many achievements, the destruction of the biosphere goes on undetected. There is an alarming mass of examples. Here are a few of them.

The richest environments on the planet are the tropical rain forests: 40 percent of them have been destroyed already. The continuing average rate of destruction by felling and burning is 20 hectares per minute. The most valuable of the tropical forests, and the richest in plant and animal species are the lowland rain forests and they are being destroyed at a much faster rate. By the end of the century, if current rates of destruction continue, the lowland forests of Malaysia, Indonesia and the Philippines are likely to have disappeared. The importance of this loss, which would be without precedent in recorded history, can be surmised from the fact that as many as half of the world's land species live only in tropical rain forests.

Desert or semi-desert already forms 43 percent of the earth's land surface. Thirty million square kilometers more, an additional 19 percent is threatened with desertification. This is a loss of potentially productive land that we simply cannot tolerate.

The wetlands and shallows along the shores of oceans and seas are being degraded and rendered less productive by dredging, dumping, pollution and "shore improvement." Increasing human populations and industrial developments center on the coastal zones and the future of these areas in terms of biological productivity and amenities is severely threatened.

Immense quantities of fertile soil are being lost each year from the highlands of Asia, Latin America and Africa; for example 240 million cubic meters a year from Nepal; 426 million tons a year from Colombia; more than a billion tons a year from Ethiopia. This soil is not just lost from site; it may clog rivers and canals, fill reservoirs and smother coastal coral reefs. Losses are not simply due to erosion:

in the USA alone 10,000 km^2 of arable land are taken over each year by industry and urbanization.

It is not only the physical basis of ecosystems that is being destroyed. More than a thousand vertebrate species and subspecies and 25,000 plant species are threatened with extinction. The losses of invertebrate animals whose habitats are being eliminated in their entirety are difficult to estimate, but it is suggested that from half a million to a million species will have been made extinct by the end of the century.

The centers of origin of our invaluable crop plants are being devastated all over the world. Many varieties of rice, maize, sorghum, millet, yam and cotton are almost extinct. If these genetic strains are lost, so is the main opportunity further to improve the productivity and environmental tolerance of these mainstays of human life.

At least 25 of the world's most valuable fisheries are seriously depleted. The resulting loss of potential production is about 7 million tons or some 10 percent of the current world annual catch. In addition, 7 million tons of fish is killed accidently and thrown away each year. Some other fisheries are now so fully exploited that they may be depleted within a decade, due to the effects of exploitation alone or in combination with those of pollution and habitat destruction.

I find it depressing to recite this litany of waste and destruction; not only is it alarming and threatening in itself, but also a similar story has been told for decades. We seem not to have learned how to achieve conservation, or if we have, we have failed to pass on the lessons to others. Whatever the reason, one thing seems clear: if lack of money and trained people means that we cannot immediately redouble our efforts, we must at least ensure that our efforts are directed so that they have maximum effect. To that end we must position ourselves to make better choices; we must employ a strategic approach.

"Strategy" has become a fashionable word and, like "ecology," it has taken on a meaning somewhat beyond its dictionary definition. Strictly speaking, strategy refers to the planning and directing of large scale operations. To meet the problems touched upon above and thus achieve conservation in the world today certainly calls for large scale operations. Many conservation activities are themselves well planned and have succeeded in meeting their objectives. Many more have failed, or have achieved stop-gap success at best. At the global level, however, there has never been a comprehensive planning framework, a coordinated approach to setting priorities nor a sustained large scale effort to attack major problems. Unplanned, aimless operations fail to achieve their goals except by chance: the stakes are too great to rely on chance. We do need a conservation strategy for the world.

The need to tackle conservation as a world issue may require some defense—especially as the difficulties of acting internationally often discourage people and persuade them to concentrate on problems at home. If, for example, the luxuriant, species-rich tropical forests are totally destroyed; if the spread of barren deserts continues unchecked; if whales, krill, tuna and a hundred other marine species are not managed for sustainable yield, all mankind will suffer. The loss of species as yet undescribed will reduce our potential for development, the loss of food and fiber will threaten the survival of millions; the damage to our life-support systems could be crucial. The problems of the tropical forests and the deserts cannot be solved unaided by the countries in which they exist. They themselves must develop the will to solve them—and I believe they can. We in the developed countries must provide the means—and I hope we will.

The problems of the living resources of the sea obviously cannot be solved by any one country either. Some progress is being made, but not enough to forestall the extinction of some species and the depletion of many more. Unfortunately, to some exploiters, the prospect of short-term gain still seems more attractive than rational management for sustainability. It is an international task to persuade all those involved that the resources of the seas are a common heritage and a common responsibility.

None of the foregoing is meant to suggest that local and national conservation issues in North America are unimportant or that you should reduce the attention you give them; it is to suggest that global issues have a significance for all of us and that North Americans, who have given so generously in the past, must contribute even more to that extra effort that is required to achieve more conservation at the global level.

Whether they operate at the global, national or local level, conservationists must observe certain strategic principles if they want to succeed: they should decide what problems should be given priority; they should tackle the causes of those problems and not just the problems themselves; they should be alert for special opportunities for dealing with the problems and their causes; and should consolidate and follow-up. These principles provide the bases upon which choices of action must be made if we are to make the most effective use of limited financial and human resources. I would like to talk about just two of these: priorities and criteria.

What we decide are the priority problems depends on the criteria we adopt for setting priorities. Criteria are essential. We may have an intuitive feeling for what is top priority depending upon our biases and experiences, but that really is not good enough. If we wish to convince the people who can effect change and bring about action (and we must), and if we want others to cooperate in concentrating on the problems we regard as important, then it is necessary to make explicit our criteria for choosing priorities. In my view three criteria are essential: the magnitude of the loss or damage that is occurring or is about to occur, the imminence of that loss or damage and the likelihood of success, that is of the loss or damage being redressed, eliminated or avoided for a significant time.

It is difficult and perhaps irrational to attempt to apply these criteria to the choice of priorities among the three broad conservation objectives mentioned earlier. The maintenance of genetic diversity, the continuing functioning of life support systems and the good management of exploited populations and ecosystems are objectives of equal value, each of which must be achieved. Therefore criteria for priorities should be applied to problems that impede the achievement of any one of those broad objectives.

In considering priorities for action to prevent extinction of species, (loss of genetic diversity) the magnitude of the loss is greater the higher the taxonomic unit that is threatened. Thus it is more important to save a species that is, in fact, a monotypic genus than a species that is one of a multitypic genus. For example, the bowhead whale (*Balaena*) and the humpback whale (*Mcyopters*), both endangered, should, if necessary, be given priority over the blue whale (*Balaenopt-*

era) whose genus is shared by the fin, minke and Bryde's whales.

The imminence of loss should also be a significant element in choosing priorities. It is more important from the global point of view to take action to save a species that is endangered throughout its range than one that is endangered in one country on the periphery of its range. Action to save endangered species should take precedence over action to save vulnerable or rare species. These may be difficult choices, but logic compels that they should be made.

In considering priorities for action to protect vital ecological processes, it is necessary to consider the extent to which a problem impinges on global, regional or local processes—at the global level affecting basic biogeochemical systems in the atmosphere or oceans or regionally and locally the healthy, productive functioning of ecosystems. Problems having global effects require priority attention. In a sense, of course, the distinctions between levels and extents of effects are more apparent than real. The consequences of pollution and soil degradation on a small watershed are not necessarily confined to it, although the remedial action must be applied within it. What is important is that the attack on problems that are widespread because compounded of many small, similar problems must be planned and implemented on a broad scale and such action must have high priority.

The imminence of threats to vital ecological processes is difficult to quantify. At what point, for example, does the process of accelerated eutrophication become unacceptable or irreversible? If the maintenance of life-support systems is to be assured, more needs to be done to define internationally accepted standards of environmental quality that reflect knowledge of thresholds of irreversibility. In any event, however, the later that remedial action is undertaken, the more costly the measures required to ensure an acceptable rate of recovery.

There are difficult choices to make in defining the top priority actions to ensure the continuing productivity of exploited populations and ecosystems, but a significant measure of the importance of a problem is the degree of human dependence upon the populations and ecosystems in question. If a plant or animal species is exploited for human subsistence and no substitute can readily be employed, its good management is of the highest priority. Conservation of populations exploited by human communities for both subsistence and trade may rate an equally high priority, but exploitation for commercial purposes alone would require a lower priority. Another factor to be considered in this connection is the number of persons that depend upon the species either for subsistence or trade.

The imminence of threat to an exploited population should be considered in terms not only of specific reproductive characteristics that will affect its ability to recover from depletion, but also of the stable functioning of the ecosystem of which it forms a part and the quality of the environment in which it exists. Other things being equal, priority attention should be given to species with a low reproductive potential, that are parts of a perturbed ecosystem and are adversely affected by destruction of habitat or environmental contaminants.

Factors affecting the likelihood of eliminating, redressing or avoiding loss or damage are much the same whether we are concerned with the survival of species, the maintenance of life support systems or the good management of exploited species. Timely action and public support are the keys. Problems can be solved more quickly and cheaply if they are attacked in time; and for every species and ecosystem there is a practical point of no return. Without public support, no fundamental conservation action can be begun, let alone sustained. This suggests that every proposal for conservation action must include a public information component. Only with knowledge and understanding is there a hope for lasting achievement of conservation objectives.

Founding a strategy upon a definition of the importance of the problems to be met, we must next decide where the priority actions thus determined are to be directed—what are the targets? Lasting success is more likely if the target of conservation action is a cause rather than a symptom of the problem. Imminence of threat to important species or ecosystems may demand immediate action, but this should not divert us from getting at the roots of conservation problems. The basic cause of conservation problems is most often lack of facts, lack of understanding, lack of will, and—throughout most of the developing world at least—poverty. Of the four root causes noted, poverty is of overwhelming and special importance and I will return to it later. Of the other three, lack of facts and lack of understanding contribute to lack of will and are therefore fundamental causes of lack of conservation.

Here we must consider who it is that lacks facts and understanding relevant to the achievement of major conservation objectives. I suggest that the situation is as follows: the facts that many species and ecosystems are being depleted, degraded or destroyed are reasonably well known to a handful of people and the same people understand in general terms the importance of species and ecosystems and what is required for their continuing health and stability. But these facts and this understanding have not been effectively communicated to enough decision makers or to enough of those who influence decision makers. The need, then, is to extend knowledge and understanding to those who make or influence decisions. It is thus that we must define our targets for a top priority activity—the dissemination of information and understanding. On the basis of knowledge and understanding, the will to conserve will emerge and be expressed in law, public policy and personal action.

Where fundamental gaps in knowledge remain there is, even among the most ardent conservationists, a residue of uncertainty. We cannot yet, with confidence, predict the effects of the elimination of tropical forests or the sterilization of regional seas on global life support systems. But what should be the politics of uncertainty? Wait and see? Let disaster itself be the proof that it will occur? Better by far to reduce the risk by being prudent. Here again the targets of conservation action must be the decision makers. They must be helped to develop the vision and the will so that they will act now to curb the threats to global life support systems.

Conservation is for ever and conservation action must be consolidated and followed up. The action of today is never sufficient for tomorrow. A breakthrough in public understanding must be followed by transferring popular will into law. Laws must be enforced but they can be effectively enforced only if public understanding is sustained. A new generation that must absorb knowledge and understanding appears every 25 years. The need to communicate is unending. The effectiveness of law and public policy must be continuously assessed. How may law and policy be improved? How should they be extended to meet global problems? A world strategy for conservation must provide for continuing action if conservation is to be achieved.

I said earlier that the problems of the tropical forests and the deserts could not be solved unaided by the countries where they exist. The references were indicative: you could add the health of coral reefs and mangrove swamps to name only two more. Later, I asserted that poverty is of overwhelming importance as a root cause of lack of conservation. The two statements are, of course, only different ways of making the same point and I want to return to it now.

The strongest human motivation is to satisfy basic needs. Lacking sufficient food and water, adequate shelter and clothing and reasonable health no man will seriously concern himself with less immediate problems. Only when those needs are met and life seems assured, will man's thoughts turn to questions more remote—such as life next year, life for one's children and one's children's children. The primary concern of a billion people is survival. Their everyday lives are shadowed by the threats of starvation, disease and natural disasters. These are the people who struggle to produce a skimpy crop on land submarginal for cultivation and cut their pitiful pittance of fuel from dwindling forests. These are the people who, seeking a modicum of cash, poach ivory and rhinoceros horn, dynamite fish in coral lagoons, and steal baby chimps from their mothers. Who can blame them? They suffer from underdevelopment.

Conservation is most urgently needed in those parts of the world where underdevelopment precludes any popular understanding of the need. The dominating prerequisite for global conservation therefore, is development—development that provides for man's basic needs and satisfies his cultural aspirations without depleting resources or destroying the systems that support life. The nature of such development—it has been termed eco-development—is not yet well worked out, but some principles are clear. By definition, eco-development conserves rather than depletes resources, and maintains rather than degrades the quality of air, soil and water. It is labor-intensive and energy-saving. It exploits indigenous materials and skills. It is development that evolves with the participation of the people involved and is aimed primarily at meeting their needs rather than generating profits for others. If it is to succeed and spread, a new sort of development aid will be needed to help it take hold and it will require a world order that respects and fosters the economic autonomy of communities as well as their right to political self determination. All this may seem far from the traditional concerns of this conference, but I venture to suggest that it is highly relevant to the future of conservation.

Consider for a moment the case of Madagascar as described by Jolly (1978). Of its roughly 715 vertebrate species, some 575 are endemic; so are at least 80 percent of its 10,000 flowering plants. Six families of plants, four of birds and five of mammals are confined to Madagascar. When man reached Madagascar little more than 1,000 years ago, the island continent was wholly forested. The last full aerial survey, published in 1958 showed 20 percent forest cover, half the proportion of forest that exists in the United States from Maine to Virginia, which cover the same area. The keynote speaker at the conservation conference recently held in Tananarive said "We are perfectly aware that none of our suggestions, none of our practical advice, will achieve anything for the protection of nature, if the people do not have land which they can cultivate in perpetuity in order to live." The director of Water, Forest and Soil Conservation presented a detailed proposal for protection of 580,000 hectares of parks and reserves. Over half of the roughly

$2.5 million requested would be used for the formulation of land-use plans and the development of agricultural alternatives for people living around each reserve. According to Jolly, if nothing is done, the peasants who now roll back the forest will have the same problem in 10 years time as they do today: eroding watersheds, sterile soil, dwindling firewood supplies. The only answer then will be planted pines or eucalyptus. The option of saving the Malagasy forest communities and hundred or even thousands of Malagasy species will be gone.

This is indeed a time of crisis for resource conservation, but it is also a time of opportunity if we choose to grasp it. Public awareness of the uniqueness and significance of the ecosystems that are the product of millenia of evolution continues to grow; the need to face the problem of their conservation in an organized fashion and as a matter of urgency is achieving wider recognition; and, finally, the perception of conservation and sustainable development as inextricably linked and interdependent activities is now at least the subject of dialogue between conservationists and developers.

When I addressed the 40th North American Wildlife and Natural Resources Conference in 1975, I proposed that to clarify our objectives and perfect our mechanisms for management of resources and the environment at the international level was the primary challenge of the future. In March 1980 the International Union for Conservation of Nature and Natural Resources (IUCN), with the cooperation of the World Wildlife Fund and the United Nations Environment Programme, will publish a World Conservation Strategy. In what I have said today I have forecast some of the principles that will be embodied in the strategy. While much will still remain to be done, I believe that the launch of the strategy will facilitate significant steps toward meeting the challenge. I hope we may all take those steps together.

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Energy Mining Impacts and Wildlife Management: Which Way to Turn

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1. Introduction

Opening Remarks and Purpose

Our intent in developing this topic was to evaluate activities associated with energy mining in sufficient detail so that the major impacts of these operations on wildlife resources could be identified and quantified. From this quantification analysis, we planned to develop a set of guidelines and suggestions for persons vested with wildlife resource management responsibilities or interests, to aid in major decision processes related to energy developments and their impacts on wildlife.

Two themes emerged from our review and evaluation:

1. Each of us, having worked for a number of years in research and planning fields involving energy mining, felt confident that sufficient hard data were available to address impacts of energy mining on wildlife resources. We were humbled, for we found little quantified data useful for preparing guidelines.
2. Most research papers, information contained in environmental statements, and other literature are not relevant to present day needs for impact assessment. When available, research observations of changes in populations and com-

munities resulting from mining activities were made at mines operating under a set of regulatory requirements lacking the protective and monitoring rigor of recent laws. Future energy mining in the Unites States will be performed in accordance with the Surface Mining Control and Reclamation Act of 1977 (30 U.S.C. 1201), related Office of Surface Mining regulations and state implementation regulations, the Clean Air Act Amendments (42 U.S.C. 1857-1857F; as amended), and the Clean Water Act of 1977 (33 U.S.C. 466 et seq.). These regulations impose standards and compliance requirements that should markedly decrease or eliminate some of the more serious impacts that are recorded in the literature. Canadian mining programs are also becoming sensitive to environmental protection measures.

Thus, the adage that study of the past reveals insights into the future is not really pertinent in this case because the energy mining regulatory atmosphere has imposed changes that can reduce impacts on wildlife and create opportunities for long-term improvement of wildlife habitats. We as wildlife managers, then, are at a point of opportunity provided by legislation. To capitalize on this opportunity we must take clear actions to establish protective stipulations and land use priorities—suggestions are given in section 5 of this paper.

In section 2, the magnitude of energy mining as compared to other land uses at both regional and national levels is discussed. In sections 3 and 4 we treat, in general terms, the primary mining activities that cause impacts to wildlife and gauge the relative severity of these effects assuming existing mining practices. Those of you familiar with energy mining operations and the general types of effects on wildlife might wish to review the three matrices at the beginning of section 3, and proceed directly to section 5. Others will find it useful to read through the general descriptions contained in sections 3 and 4.

Scope

Our considerations have been limited to present and future energy mining programs within the United States and Canada. Because of our familarity with information and regulations in the United States, examples and remarks are disproportionately skewed toward the United States. Surface and underground coal, uranium, oil shale, and tar sand mining operations are included in the definition of "energy mining," as is in situ gasification conversion. An analysis of the relative future contribution of each of these operations to wildlife habitat disturbance has caused us to focus primarily on coal, uranium, and oil shale mining. We have excluded impacts related to energy conversion or utilization. Our definition of the term "wildlife" includes both fish and wildlife resources.

How successful wildlife managers are in initiating and gaining local acceptance of wildlife management programs depends in part on public awareness of wildlife requirements and on their appreciation of wildlife resources. Local public attitudes toward wildlife in an area with an energy mining program can markedly influence the success of management plans. For instance, if community leaders have a wildlife ethic, the outcome of wildlife management activities can be very different than in a community where a significant number of workers have lost their jobs because of a past judgement on an environmental issue. Public attitudes, combined with possible secondary impacts on wildlife populations resulting from recreation, poaching, road kills, and habitat usurpation by the increased population of miners and support groups, has caused us to also consider sociologically related impacts.

2. Magnitude of Energy Mining as Compared to Other Land Uses

Introduction

The mining of energy resources in North America is a many-faceted environmental perturbation. To understand the related problems and opportunities for wildlife resources, we must first place this use of the land in its proper perspective by examining the scope—frequency and amplitude—of energy mining relative to other land uses. The 8.5 million square miles (22.0 million km^2) of the North American continent supports a population of over 300 million people that is doubling every 70 years. Associated life requirements generate increasing competition for a finite land resource being taxed to produce food, fiber, fuel, and absorb wastes at an inflating rate.

World energy requirements are projected to increase at an average annual rate of 2.9 percent through the end of this century (Dupree et al. 1976). The United States alone is projected to consume between 117–192 $\times 10^{15}$ British thermal units (Btu) of energy annually by the year 2000. Of this amount, petroleum is projected to provide 40–50 percent, nuclear sources 15–25 percent, natural gas 17–20 percent, and coal 18–23 percent (Dupree et al. 1976, U.S. Federal Energy Administration 1976). National policy in the United States is directed toward reducing the dependence on foreign energy imports by increasing domestic energy production. However, the production of domestic petroleum and gas has been declining since the early 1970s, which has caused the United States' policy makers to place increased emphasis upon coal and uranium resources (U.S. Bureau of Land Management 1978a). A similar scenario has been suggested for Canada (Alberta Department of Energy and Natural Resources 1976).

In the remainder of this paper, we will focus on: (1) the development of coal, uranium, and oil shale energy sources; (2) the relative magnitude of these land uses; and (3) placing in perspective those issues related to wildlife resources.

Cumulative Land Use Devoted to Energy Mining

Mining for coal in North America began in the 1800s in the northern and central Appalachian coal mining regions (Figure 1). At the start of the United States Civil War, wood still provided 80 percent of the energy consumed on the continent (Table 1). By 1900 however, coal had replaced wood as the major energy source, and became the energy base for economic and industrial growth in the United States. Oil and gas began to supplant coal by 1920. Atomic energy was discovered in the 1940s and uranium mining became more widespread with three nuclear power plants in operation by 1961. By 1975, nuclear energy was providing 6.3 percent of all energy consumed in the United States. Coal again came of age in the early 1970s, as demand for petroleum and gas began to exceed supplies.

Between 1930 and 1971 a total of 3.69 million acres (1.47 million ha) of land in the United States (0.2 percent of the total U.S. landmass, Table 2), were mined. Energy mining accounted for about one-third of all forms of mining. In the United

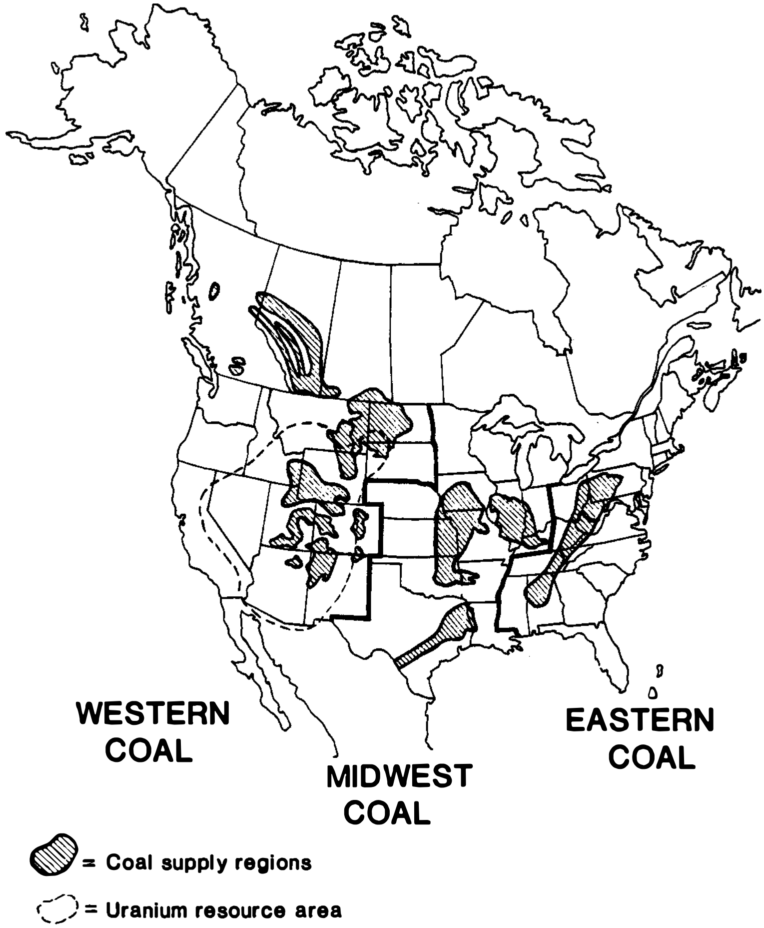

Figure 1. Coal supply regions in Canada and the conterminous United States, and uranium resources in the United States (Nielsen 1977, U.S. Bureau of Land Management 1978a, and U.S. Office of Surface Mining 1979).

States 1.57 million acres (630,000 ha) were mined for coal during this period (Table 3), and 64 percent of those lands had been reclaimed by 1971, leaving 560,490 acres (226,919 ha) to undergo a slow natural succession. While 12,800 acres (5,182 ha) of land have been utilized for uranium mining in the United States during the 41 years between 1930 and 1971, only 6 percent had been reclaimed by 1971.

Urban areas, highways, airports, and railroads, uses rendering the land unreclaimable for wildlife or agriculture, represented 4.6 percent of the total land utilization in the United States in the mid-1970s (Table 2). In contrast, mined lands, which *can* be reclaimed, represented only 0.2 percent of the total land use in the United States during the same period. Thus, energy mining to date has directly affected a relatively small proportion of the entire land area in the United

Table 1. North American energy consumption history (Evans and Tate 1975).

Year	Btus consumed: Total ($\times 10^{15}$)	Btus consumed: Per capita ($\times 10^{6}$)	Population ($\times 10^{6}$)	Major fuel: %	Major fuel: Type	Comments
1861[a]	0.5	16	32	80	Wood	Civil War begins. Whale oil to $2.55/ga. Kerosene developed.
1900	6.0	79	76	66.5	Coal	
				23	Wood	
1911[a]	14.8	160	93	75	Coal	First self-starting auto. First transcontinental air flight.
	Growth per Year—3%					
1920	19.6	186	106	78	Coal	Oil imports at 1.0 million
				18	Oil & gas	barrels per day (MBPD)
1950	34.2	225	152	38	Coal	Big changes after WW II.
				57	Oil & gas	Railroads to diesel.
1960	45.0	250	180	73	Oil & gas	Oil imports 1.8 MBPD. Arabian light @ $1.80/Bbl.
	Growth per Year—5%					
1961[a]	45.7	253	181	80	Oil & gas	First man in space. Third nuclear plant.
1970	68.8	337	203	77	Oil & gas	Oil imports 3.4 MBPD @ $3.9 billion.
				18	Coal	Arabian light @ $1.80/Bbl.
1974	73.2	352	208	77	Oil & gas	Oil imports @ 6.2 MBPD @ $24.4 billion.
				18	Coal	Arabian light @ 11.65/Bbl.
				1	Nuclear	
	Growth per year—3%					
1975	80.0	382	209			
	82–105	412	215	70	Oil & gas	Nuclear @ 6.3% of U.S. Energy
				18	Coal	
				10	Nuclear	
1984	85–133	563	237	60	Oil & gas	Oil imports @ 13 MBPD.
				18	Coal	
				15	Nuclear	
2000	90–192	720	251–300	50	Oil & gas	Turn of the century.
				19	Coal	Nuclear 55% of electric
				25	Nuclear	power.
2011[a]	110–235	765	257–350	?	?	
2025	120–250	775	265–417	?	?	

[a]50 year intervals

Table 2. Types of land use in the United States[a].

Land use	Square miles	Km²	Percent of total
Urban areas[b]	109,000	282,310	3.1
Highways and roads[c]	43,363	112,310	1.2
Croplands and farmlands[c]	643,750	1,667,312	18.2
Grasslands and rangelands[c]	1,293,750	3,350,812	36.6
Forest and woodlands[c]	917,188	1,375,517	25.9
National and State Parks, National Wildlife Refuges[d-c]	106,982	277,083	3.0
Mining[e]	5,781	14,973	0.2
Airports[e]	5,156	13,354	0.2
Railroads[e]	5,000	12,950	0.1
Total[c]	3,536,855	9,160,454	

[a]Information compiled from different sources; total may not agree with sum of components.
[b]Miller 1974
[c]U.S. Bureau of the Census 1976
[d]U.S. Bureau of Land Management 1975
[e]Paone et al. 1974

States. The Appalachian region, Illinois, North Dakota, Montana, and Wyoming have received the brunt of past energy mining activity where, in some counties, a major portion of the land has been disturbed.

Potential for Additional Land Use Allocations to Energy Mining

In the future, however, an ever increasing emphasis on the development of domestic energy resources will expand energy mining activities. Coal and uranium reserves in the U.S. and Canada are expected to provide an increasing share of the growing energy needs of these countries on into the 21st century.

Fifty-one percent of the coal reserves in the United States are in the West (Table 4), 24 percent in the Midwest, and 25 percent in the East. Not all coal reserves are recoverable. Of the strippable coal reserves, 65 percent are in the West. About 77 percent of the coal recoverable by surface mining lies west of the Mississippi River. If all the strippable coal reserves were mined, 15,803 mi² (40,930 km²) or about 0.5 percent (an average of 3 acres per mi² or 2.9 ha per km²) of the United States' surface area would be directly affected. States in the Applachian area, Alabama, Ohio, Indiana, Illinois, Oklahoma, Texas, New Mexico, Colorado, Utah, Wyoming, Montana, and North Dakota have or may have up to 6 percent of their surface areas (or an average of 40 acres out of each square mile or 39 ha out of each square kilometer) directly disturbed by some form of coal mining over the next century (U.S. Office of Surface Mining 1979). In the Midwest, 60–70 percent of a given county may be affected.

Coal reserves in Canada lie primarily in the southern portions of the country (Nielsen 1977). Mining in British Columbia is limited to small operations in the Southeast. At least 26 percent of Alberta is underlain by coal, with 20 percent of

Table 3. Land utilized and reclaimed by the mining industry in the United States for fossil fuels compared to all forms of mining from 1930 through 1971 in acres and (hectares) (Paone et al. 1974).

	Fossil fuels[a]		All forms of mining	
Type of use	Utilized	Reclaimed	Utilized	Reclaimed
Surface area mined (area of excavation only)	966,000 (403,239)	716,000 (289,878)	2,170,000 (878,542)	987,000 (399,595)
Area used for disposal of overburden and other mine waste from surface mining	320,000 (129,555)	268,000 (108,502)	733,000 (296,761)	402,000 (162,753)
Surface area subsided or disturbed as a result of underground workings	87,900 (35,587)	4,000 (1,619)	105,000 (42,510)	5,870 (2,376)
Surface area used for disposal of underground mine waste	166,000 (67,206)	20,000 (8,097)	190,000 (76,923)	21,600 (8,745)
Surface area used for disposal of mill or processing waste	31,900 (12,915)	6,480 (2,624)	454,000 (183,806)	47,100 (19,069)
Total[b]	1,570,000 (635,628)	1,010,000 (408,907)	3,650,000 (1,477,732)	1,460,000 (591,093)
Percent reclaimed	64.3		40	

[a]Excludes oil and gas operations.
[b]Data may not add to totals shown because of independent rounding.

the coal in the mountainous region being 33 percent recoverable, and the majority in the plains, where it is 50 percent recoverable. Lignitic coals in Saskatchewan are scattered near the Canadian-United States border and the lignite beds in Manitoba are confined to the Turtle Mountain region. Recoverable coal in New Brunswick is in a central 160 mi^2 (414 km^2) area. Most of the higher quality coal has been mined in Nova Scotia but some possibilities for new mining exist, especially in the northeastern coastal area. Increased new coal production in Canada is anticipated for only Alberta, where sub-bituminous deposits are comparable to the Alberta oil sands as energy sources (Alberta Department of Energy and Natural Resources 1976).

Only small parcels of land in the United States were utilized for uranium mining from the 1940s through approximately 1965. A total of about 12,800 acres (4,858 ha) have been disturbed in the western United States (Evans et al. 1978). Uranium, unlike coal, has always been in short supply with demand equaling or exceeding supplies. While the total amount of available coal is widely known and easily converted to surface acreage, the same is not true for uranium. In addition, vast quantities of coal are federally owned in the West, while uranium resources are, for the most part, on privately owned land. Ninety percent of the total recoverable uranium resources in the United States are in the West (Figure 1)

Table 4. Reserve base of coals in the United States on January 1, 1976, by region and mining method, given in millions of short tons and (millions of metric tons) (U.S. Office of Surface Mining 1979).

Region	Potential mining method		
	Underground	Surface	Total[a]
East	91,634.6 (83,112.6)	20,020.0 (18,158.1)	111,654.5 (101,270.6)
Midwest	75,302.9 (68,299.7)	29,374.9 (26,643.0)	104,677.8 (94,942.8)
West	130,039.0 (117,945.4)	91,966.1 (83,413.2)	222,005.1 (201,358.6)
Total[a]	296,976.3 (269,357.5)	141,361.0 (128,214.4)	438,337.3 (397,571.9)

[a]Data may not add to totals shown due to rounding.

(Butler 1972). If it requires 1 mi^2 (2.59 km^2) to produce 9 short tons (8.2 metric tons) of uranium from high grade, or reserve level ore, then 30,000 mi^2 (77,700 km^2) of surface sould be disturbed in the United States (5.4 acres per mi^2 or 5.2 ha per km^2) in order to deplete the known uranium reserves. Another 23,000 mi^2 (59,570 km^2) would be disturbed in Canada (U.S. Bureau of Mines 1976). New technologies such as solution mining are expected to profoundly affect the surface disturbance for uranium mining in the future.

More than 2.2 trillion barrels of recoverable shale oil are known to exist in the United States (Library of Congress, Science Policy Research Division 1975). Although these reserves underlie many portions of the nation, the principal concentration of recoverable reserves is in the Green River Formation deposits in northwestern Colorado, northeastern Utah, and southwestern Wyoming, where approximately 750 billion barrels of high grade shale oil are located (Colorado Energy Research Institute 1976). The Green River Formation occupies approximately 17,000 mi^2 (44,030 km^2). Almost 80 percent of this high grade oil shale is in the wildlife-rich Piceance Basin of northwestern Colorado, where two federal oil shale leases are presently under development; about 15 percent is located in the Uinta Basin of Utah, the site of the third federal lease; and 5 percent is in the Green River Basin of Wyoming (Colorado Energy Research Institute 1976). It is in the 1,500 mi^2 (3,885 km^2) Piceance Basin that the bulk of the oil shale production is anticipated.

A major share of the energy resources in the United States and Canada are located on or adjacent to Indian lands. In the United States it is estimated that 30 percent of the strippable coal and 40 percent of the known uranium reserves lie within Indian reservations (Simms 1979). Typical major operations include the Peabody Coal Company Black Mesa mine on the Navaho Reservation in New Mexico, the Kerr-McGee Church Rock uranium mine on the Navaho Reservation, the Anaconda Jackpot uranium mine on the Laguna Reservation in New Mexico, and the Westmoreland mine on Crow-ceded lands in southeastern Montana. Numerous other projects are planned on reservations throughout the West pending federal and tribal approval (e.g., the Exxon uranium project on the Navaho

Reservation in Arizona). Some of the largest surface mines now in operation are located in proximity to reservation boundaries such as the Decker Mine complex near the Crow and Northern Cheyenne reservations in southeastern Montana. In Canada the massive Athabascan tar sands deposits of Alberta are located in the same vicinity as the Chipewyan, Cree, and Slavey Indian reserves.

Summary

Mining has disturbed a very small portion of the surface area of North America since the industrial revolution. The mining of the two most widely used energy minerals, coal and uranium, is yet a smaller part of the total. Even with accelerated energy mining activities, the proportion of the continent's land that will be affected will be relatively minor. From a regional or local perspective, however, the marked expansion of energy mining can easily represent the principal land use change factor that the region might experience in coming decades. The resulting land use changes, especially in regions that are experiencing concentrated energy mining activities, can alter the regions' suitability for wildlife resources. This land use change issue is complex. Some of you are faced with the even more complex ecological, social, and political questions related to the transportation of the energy resource out of the mining region and the conversion of the material to electricity or other end products. In the remaining sections of this paper, however, we will focus on the wildlife issues related to the activities of extraction and local transportation of energy mining.

3. Overview of Mining Impact Pathways: A Matrix Approach

A set of activity matrices is used here to summarize mining impacts on wildlife resources and to organize the assessment of these impacts. Comprehensive matrices may be developed for a specific mine or group of mines in a given region, but quite simplified matrices are shown in Tables 5, 6, and 7 for discussion purposes. These matrices have been developed by the authors based on their familiarity with mining processes and the affected biological resources. The severity of anticipated impacts (shown as the relationship between rows and columns) is rated as (1) major, (2) moderate, (3) slight, or (-) unanticipated. Criteria for rating the various effects on a particular biotic component include:

1. Probability of the action, given current regulatory constraints;
2. Expected duration of impact (short-term vs. long-term), if it occurs;
3. Expected intensity and areal extent of impact, if it occurs; and
4. Importance of the wildlife or habitat component impacted:
   a. Recreational value
   b. Legal status (only Federal endangered or protected species are considered here)
   c. Aesthetic values
   d. Role in energy or nutrient webs or ecosystems
   e. Function in controlling dynamics of other wildlife populations.

The first matrix (Table 5) indicates the intensity or relative severity of impacts anticipated from various mining activities which are likely to occur in conjunction with individual types of mines. The rankings apply to generalized mine types, and

Table 5. Intensity of impacts from various mining activities, summarized by mine type.

Mining activity	Type of mine: Coal area surface	Coal under-ground	Coal con-tour surface	Uranium solution	Uranium small surface	Uranium large sur-face	Oil shale surface
Exploration	2[a]	2	3	2	2	2	2
Surface clearing	1	3	2	3	2	1	1
Construction of facilities	2	2	3	3	3	2	2
Excavation	1	3	2	–	3	1	1
Mineral removal	3	–	2	2	3	2	2
Mineral storage	2	2	3	3	3	2	2
Mineral transport	1	2	3	3	3	3	2
Operation of support facilities	2	2	2	2	3	1	1
Waste materials containment & disposal (including sediment)	2	2	2	3	3	1	1
Personnel transport	2	2	2	3	3	1	1
Employment	1	1	2	3	3	1	1
Reclamation	1	3	2	3	3	2	1

[a]1 = Major, 2 = Moderate, 3 = Slight, – = Unanticipated or insignificant.

relative severity will often vary with site-specific mine operations and local environmental factors.

The second matrix (Table 6) relates these same mining activities to an assortment of general impact mechanism categories, which directly or indirectly lead to wildlife impacts. These impact mechanisms represent the "common denominators" of the mining activities, or the basic recognizable factors which in turn result in impacts on wildlife. With this approach one can develop a comprehensive site-specific impact analysis for a particular mine operation. For example, vegetation removal (surface clearing) will generally have the same effect upon wildlife whether the vegetation was removed for an access road or for the entire pit area. The magnitude of the effect will vary, however, depending on the type and amount of vegetation removed, the amount of time before vegetation is reestablished, and other site-specific environmental factors.

The impact ratings on the third matrix (Table 7) reflect the relative importance of the effect of various impactors on biotic components. These may need to be modified to fit the site-specific aspects of a particular operation. The ratings shown reflect normal mining procedures conducted in compliance with existing environmental regulations. Where impacts may result from mining accidents, such as chemical spills, the rating should reflect not only the severity of the expected

Table 6. Relationship among major mining activities and mechanisms of impact on biotic resources.

Impact mechanism	Exploration	Surface clearing	Constr. of facilities	Excavation	Mineral removal	Mineral storage	Mineral transport	Operation support	Waste material	Personnel trans.	Associated pop.	Reclamation
	Mining activities											
Generation of airborne materials	3[a]	1	3	2	3	2	2–3	3	2–3	–	3	3
Changes in ground water quality	3	–	–	3	2	–	–	3	2	–	–	–
Changes in surface water quality	3	2	3	–	–	3	3	2–3	1–2	–	–	3
Changes in water supply	3	2	–	3	–	–	–	2–3	–	–	2	2
Changes in soils	–	1	2	–	–	–	–	3	3	–	–	1
Changes in vegetation	–	1	2	–	–	–	–	3	3	–	–	1
Changes in topography	–	1	–	1	2	–	–	–	2	–	–	1
Changes in land use practice	3	1–2	3	–	–	–	–	–	–	3	1	1
Solid waste disposal	–	–	3	–	–	–	–	2–3	2	–	–	–
Fires	–	3	–	–	–	–	–	3	–	–	3	3
Direct effects on wildlife	–	2	3	–	–	–	2	3	2–3	1–2	1	–
Human presence effects	3	3	1	–	2	–	3	1–2	–	2	1	2

[a]1 = Major, 2 = Moderate, 3 = Slight, – = Unanticipated or insignificant.

impact, but also the likelihood of the accident occurring. It should be noted that in many instances the likelihood of impacts on threatened or endangered species would lead to imposed constraints on the proposed mining operation, thereby mitigating or avoiding these same impacts.

The general, overall effects of many mine activities will be similar, regardless of site characteristics. Activities such as surface clearing will prevent or reduce the utilization of an area by animals regardless of the types of vegetation removed (see changes in vegetation, Table 6). Impact assessment depends on the mineral to be mined and the mining method(s) utilized to extract the mineral. For example, a solution uranium mine will have a lesser impact (in terms of areal extent) on vegetation and soil removal than will an area surface mine for coal or an open-pit oil shale operation. The chance of contamination of runoff or water supplies by toxic substances will normally be greater for oil shale, uranium, and eastern coal mines than for western coal operations.

Adequate evaluation of the effects of a particular mining activity on wildlife resources requires consideration of site-specific factors including:

Table 7. Effects of impact mechanisms on wildlife resources.

	Impacted wildlife and habitat									
Impact mechanism	Threatened & endangered (when present)	Migratory waterfowl	Raptors	Other birds	Ungulates	Furbearers	Small mammals	Fish	Terrestrial vegetation	Aquatic vegetation
Airborne materials	3[a]	–	3	3	3	3	3	–	3	–
Ground water quality	–	–	–	3	2	2	–	3	–	–
Surface water quality	2	1	3	2	1	2	3	1	3	3
Water supply	1	2	–	3	2	3	–	2	–	2
Soils	–	–	–	–	–	–	3	2	1	2
Vegetation	1	–	2	2	1	2	2	–	–	–
Topography	1	–	2	3	1	3	3	–	2	–
Land use practices	1	2	2	2	1	3	3	–	–	–
Solid waste disposal	–	2	–	–	–	–	–	1	2	2
Fires	3	–	3	3	2	3	3	–	1	–
Direct effects on wildlife	1	–	2	–	1	2	3	–	–	–
Human presence effects	1	3	1	3	2	2	–	–	–	–

[a]1 = Major, 2 = Moderate, 3 = Slight, – = Unanticipated or insignificant.

1. Species of fish and wildlife present and their interrelationships;
2. Seasonal use of the area by wildlife (e.g., winter, transitional, or summer range);
3. Unique wildlife uses of the area, such as reproduction, epigamic display, migration, or wintering;
4. Availability and condition of adjacent habitats;
5. Physical size and expected duration of the mining operation;
6. Relative importance to wildlife of the affected habitat; and
7. Time frame and extent of other related activities in the vicinity.

Significance of Various Mining Activities

The mining activities shown in Table 5 are discussed below as they relate to potential wildlife impacts.

Exploration. Exploration seldom causes major direct impacts on local wildlife. Normally exploration activities are widely scattered and are of short duration on a given area; thus, the effects of human presence, traffic, noise, water consumption for drilling, dust, and habitat disturbance are seldom significant if appropriate operating procedures are followed. On the other hand, major indirect impacts may result from the improved access created by extensive exploration activities. For example, most of the nonhighway access to remote areas in southeastern Utah was created by uranium exploration in the 1950s. As a result, off-road vehicles can and do travel almost anywhere in this region, often to the detriment of wildlife and archaeological resources, and soil stability. Improved access is much less a problem with large, individual mining developments where intensive exploration is followed shortly by production and reclamation.

Surface clearing. The physical destruction of wildlife habitat and loss of such habitat for the life of the mining operation is one of the most important impacts, particularly for large surface operations.

Large amounts of vegetation are destroyed or changed during surface mining activities and to a lesser extent during underground mining, not only as a result of the actual mining (removal and storage of overburden from the ore body) but also due to construction of transportation and utility facilities, ancillary facilities, and runoff control structures. According to the Draft Environmental Impact Statement on the Federal Coal Management Program (U.S. Bureau of Land Management 1978a), with no new federal coal leasing and a medium level of production between 1976 and 1985 from existing leases in the Powder River Basin of Wyoming, an estimated 500,000 tons (450,000 metric tons) of range forage, 3,400 game mammals, 2,500 game birds, 170 predators, and a multitude of small mammals, birds, and reptiles will be lost. For comparison purposes, under similar leasing and production conditions, the projected game mammal losses for this and other major coal regions appear in Table 8.

Secondary impacts from surface clearing include increases in dust and sediment from the site; these effects may be highly significant in specific cases, especially to aquatic organisms.

Construction of facilities. Construction of buildings, parking areas, conveyors, haul roads, tipples, and other facilities seldom creates major additional impact

Table 8. Potential losses of selected types of wildlife due to habitat loss based on no new federal leasing—mid-level production 1976–1985 (excerpted from U.S. Bureau of Land Management 1978a).

	Potential loss of:		
Coal region	Game mammals	Game birds	Predators
Northern Appalachian	18,110	60,000	520
Central Appalachian	11,060	40,000	320
Southern Appalachian	10,710	40,000	310
Eastern Interior	15,780	50,000	530
Western Interior	4,920	30,000	330
Texas	14,270	50,000	470
Powder River	3,410	2,500	170
Green River-Hams Fork	1,650	13,100	160
Fort Union	1,780	5,900	80
San Juan River	50	6,200	90
Uinta-Southwestern Utah	28	5,600	60
Denver-Raton Mesa	460	5,800	60

beyond the initial clearing activities unless such facilities are dispersed and interfere with local wildlife movement patterns. In the West, fenced access roads or lengthy conveyors may result in significant impacts. The improper construction and maintenance of sediment ponds and roadways may substantially impact aquatic habitat and wildlife. Finally, the construction phase usually involves the largest influx of workers, and construction-related populations are typically associated with more severe impacts on wildlife than the permanent workforce.

Excavation. Excavation of the site to reach the mineral resource will lead to wildlife impacts through major changes in local topography. Large coal mining operations in the western United States and Canada will often result in the reclaimed surface being substantially below the original surface, thus creating new landforms around the edge of the operation. Perhaps more importantly, many large mining operations for minerals other than coal will be open pit without backfilling. Thus, some uranium and possibly oil shale mines will never be reclaimed according to standards for coal operations. Associated with these open pit operations are extensive dumps for disposal of the overburden and waste materials. In most cases such deposits will be reclaimed, but under less stringent regulations than the 1977 Surface Mining Control and Reclamation Act which pertains to surface coal mining.

Mineral removal. Removal of the mineral itself seldom causes major wildlife impacts aside from those of related activities. However, removal of minerals may disturb important local aquifers that contribute to surface springs and streamflow.

Mineral storage. Open storage of minerals, which is common in many mining operations, contributes to air and water quality deterioration which may directly or indirectly affect several types of wildlife. Although impacts from mineral storage are not usually of major significance, they may be quite important in specific situations, particularly where threatened or endangered aquatic species may be affected by downstream water quality.

Mineral transport. Transport of the mined products is most significant for large, western surface coal mines where lengthy railroad spurs are commonly required. In other cases lengthy haul roads may be constructed to remote load-out facilities on existing railroads. Such transportation corridors commonly contribute to increased roadkills of wildlife, interrupted wildlife migration patterns, and additional habitat losses.

Operation of support facilities. The extent of on-site support facilities differs substantially from one type of mining operation to another. Uranium and oil shale operations commonly involve on-site processing plants while coal mines and small uranium operations normally involve shipment to distant processing or conversion facilities. In this context we are not addressing mine-mouth conversion facilities which may accompany some large coal mines.

Mineral processing commonly requires substantial amounts of water as do other mining activities such as dust control. It has been estimated that coal development in the Powder River Basin will require about 55 acre feet of water per million tons of coal extracted for such uses as dust control and revegetation (U.S. Bureau of Land Management 1978a). This value is small compared to mineral processing requirements.

The importance of water diversions and quality changes to aquatic resources cannot be overemphasized, particularly in the West where aquatic resources have already been drastically altered by extensive water diversion and storage systems. Impoundment, diversion, and withdrawal have changed natural flow regimes, often with detrimental effects on fish.

Waste materials containment and disposal. Most mining operations do not have major waste disposal problems. However, uranium and oil shale operations involving on-site processing produce enormous quantities of tailings and waste rock which usually are saline or acidic in nature or otherwise undesirable. Tailings ponds and waste dumps may cause substantial degradation of local air and water resources.

Personnel transport. Large scale mining operations typically employ 100 to 300 people and even greater numbers of workers during construction. The heavy traffic of individuals driving to a mine often leads to numerous collisions with wildlife and increased poaching. These impacts are considerably reduced where mass transportation is provided for workers and where shift changes do not coincide with early morning and late evening wildlife activity periods.

Employment. The sizeable work forces of major mines bring with them substantial growth of local communities including many secondary jobs in associated industries. This overall contribution to local employment and community growth normally results in temporary construction camps near the mine site, increased development of permanent housing and mobile home parks, conversion of small farms to residential areas and other urban uses, and further reductions in habitat for most wildlife species. Additionally, the increased local population creates heavier hunting, poaching, and other outdoor recreation related disturbance pressures on wildlife populations.

Reclamation. Reclamation activities, while mitigating the overall disturbance caused by mining, may contribute other long-term impacts where the characteristics of the reclaimed area and postmining land use differ drastically from the premining condition. Reclaimed areas may differ in vegetation composition and diversity, location and number of water sources, topography, and land use.

Topographic modifications will be less of a problem than in the past due to current mining technology and regulations. The 1977 Surface Mining Control and Reclamation Act requires that the mined areas be returned to "approximate original contour." Thus, the final topography of existing mines will ultimately blend with the surrounding topography. On the other hand, mountain top removal and mining of uranium and oil shale can lead to major changes in local topography since different regulations and processes are involved.

Even with restoration of the mined area to "approximate original contour" and the use of primarily native plant species, major impacts on wildlife may be expected when reclamation is accompanied by greatly reduced vegetative diversity, eradication of browse species, and increased intensity of use by domestic livestock. In the Midwest, surface mined areas have commonly been planted to agricultural crops, thereby reducing the vegetative diversity and habitat complexity relative to premining conditions.

4. Impact Mechanisms

The impact mechanisms listed in Tables 6 and 7, their relationship to wildlife populations, and related technological controls are discussed in the following section.

Airborne Materials

Although dust problems around mines are common and comprise one of the more conspicuous aesthetic impacts, the airborne materials are normally of little consequence to wildlife living away from the mine. In most cases, other mechanisms will affect wildlife at a greater distance from the mine and with greater severity. Technological actions can control most of the fugitive airborne material.

Ground and Surface Water Quality and Quantity

The water quality of local aquifers may be affected by mining operations which intersect the aquifer or by drilling and other operations which allow mixing of water between aquifers. Although the contamination of ground water supplies may severely restrict the domestic utilization of such water, wildlife are rarely affected unless local springs are contaminated through an aquifer. Known recharge areas are protected under new federal and state laws and regulations in the United States.

Degradation of water quality due to increases in siltation or toxic substances in local streams and impoundments may adversely affect certain wildlife such as waterfowl, fish, and aquatic invertebrates. Examples of changes in community structure are found in studies of acid mine drainage. Acid mine drainage, characterized chemically by low pH, low alkalinity, high sulfate, and high iron content, as well as sedimentation can affect the benthic community in streams. The general case is that disturbance causes reductions in diversity, evenness, and the number of taxa present in relation to the severity of the water quality degradation (Winger 1978). Thus, benthic community parameters are often used in assessing the severity of cumulative effects of mining on streams (Matter et al. 1978). Important shifts in taxonomic composition also occur, with tolerant species dominating more severely stressed habitats (Preston and Green 1978, Winger 1978). In general, benthic community parameters tend to become more normal as water quality improves, but the effects of acid mine drainage may be noticeable years after abandonment (Matter et al. 1978).

All major energy mining states now have stringent water pollution control laws applicable to mining. The Surface Mining Control and Reclamation Act brings nonpoint pollution sources under regulation for coal mining. The control of both point source and nonpoint source discharges from mines and mine related activities for operating mines has greatly reduced energy mining impacts on surface water quality. Continued improvement in this area is anticipated, although accidental spills and discharges will still occur. Uranium mining and milling operations, oil shale mining and processing operations, and uranium solution mining operations have a high potential for significant local impacts if accidents occur. Water quality changes can usually be predicted during the mine planning stages and minimized through technical controls. Direct impacts on aquatic systems are normally localized except for water quantity and acid-mine waste related problems.

The loss or modification of a water supply and its associated vegetation can eliminate or reduce not only the resident wildlife populations but also wildlife from surrounding areas, even though these animals may rely on the riparian area for a relatively short period of time (e.g., during nesting, brooding, migration, or spawning). Many game species use stream courses for water, escape cover, and/or food. These areas are of major value where rare and endangered species exist. In addition, riparian areas are often utilized as corridors for wildlife movement from one area to another; disruption can create barriers to normal movement and reduce overall carrying capacity of surrounding habitats. In these cases, mining or disturbance of such water should not be allowed unless a nearby replacement is provided.

Large scale surface mining often requires the rerouting of small streams. The effect of such rerouting depends on the quality of the new stream channel. High quality streams typically have stable banks and contain a diverse mixture of spawning areas, pools, and rubble riffles. New stream habitat should also contain these features if degradation of habitat is to be prevented. Regulations now preclude such relocations without approval of a suitable reclamation plan and design.

Adoption of proper construction techniques can nearly eliminate additional suspended solids. Basically, this involves construction of the new stream channel with "coffer" dams (plugs) left in each end, pumping problem ground water during construction to settling ponds before it enters the streams, and riprapping and/or revegetating the bottom and sides of the new channel before the coffer dams are removed. In addition, proper planning and reclamation can recreate the conditions necessary for rapid establishment of a healthy and useful aquatic community, although initially the community will be different from the original. The most important part of the plan is the physical re-creation of a pool-riffle complex, with the riffles being riprapped to provide structure and oxygenation.

Streams that have been severely dewatered are more prone to freezing with obviously drastic effects on fish populations. Riffle areas, which are generally considered to be important areas for invertebrate production in streams, are the naturally shallow areas of streams, making them the first to dry or freeze when stream levels are low.

Adverse impacts on wildlife species could result from the establishment of tailings ponds commonly associated with uranium mills. If care is not taken to prevent wildlife access to these ponds, mortality to wildlife, particularly waterfowl, could result because these ponds are often highly toxic or acidic.

Mining activities may increase surface water by using water from underground aquifers. However, this aquifer pumping is likely to reduce the surface discharge of the aquifers elsewhere. Provided the discharged water is of suitable quality and reasonably constant supplies are maintained, the additional surface water could be beneficial to wildlife. Creation of pond or lake habitats as has occurred in the Midwest, can have positive effects on certain wildlife groups, but unless the newly created aquatic habitat is permanent, long-term benefits for wildlife would be minimal. In areas where precipitation exceeds evaporation, there is a good possibility of establishing productive, high quality impoundments. For example, Sandusky (1978) reported 35 waterfowl broods on 242 acres (98 ha) of newly reclaimed strip mine ponds in Illinois. Strip mine pits sometimes provide excellent fishing. With proper planning and control, a majority of the postmining aquatic habitats could be productive and of benefit to society with minimal management efforts. In semiarid areas, permanent aquatic habitat will not be as easy to establish because of reduced precipitation and potentially large evaporation losses.

Soils

Erosion and erodibility of soil materials may be increased during the removal, reapplication, and possibly the stockpiling phases of soil handling. Erosion may increase if soil materials are left exposed for a considerable time following removal of vegetative cover. Excessive handling of soils during salvage operations can result in an increase in the erodibility of the soil resource due to destruction of soil aggregates. In either case, the soil available for revegetation can be of reduced quality.

Soil handling activities can provide for more amenable soil properties where soil structure inhibits plant growth. On the other hand, where premining soil structure promotes plant growth, this structure could be degraded by handling operations, resulting in a poor soil environment for revegetation. Compaction of soils during handling may lead to poor soil structure in which the number of large soil pores is decreased and the number of small pores is increased. This situation can lead to reduced moisture infiltration and consequently to reduction in vegetative cover and an increase in erosion. The change in overall pore size could also reduce soil aeration in much the same way. Physical mixing of soil materials during handling operations can serve to blend the properties of different soils or soil horizons when desirable.

Large, long-term topsoil storage piles are normally considered undesirable because of adverse effects on the native microbial populations. In most surface mining operations, however, this impact is avoided by: (1) direct transfer of most salvaged topsoil to areas ready for revegetation, thus avoiding stockpiling; and (2) disturbance and reclamation of a limited area each year, thus allowing natural invasion of microbial populations from adjacent undisturbed or previously reclaimed areas.

The spreading of topsoils in uniform versus varied thicknesses can also be used to modify postmining vegetation. For example, in northeastern Wyoming, uniform spreading of topsoil will probably preclude reestablishment of such communities as sandhill grasslands and scoria grasslands or savanna which require a coarse substrate. A variable micro-site soil preparation plan is important to the development of natural plant associations that are often tied to specific soil-parent material types, particularly in arid and semiarid regions of North America.

Topography

Changes in topography resulting from surface mining can play a major role in determining which wildlife species recolonize the area after mining ceases. Topography strongly influences microclimate and microhabitat by governing the distribution of solar radiation received, the degree of exposure to prevailing winds, and runoff patterns. Over any specific area, variations in surface microclimate will influence the distribution of vegetation and wildlife because individual organisms do not interact with large scale climatic patterns but rather with the climate close to the ground.

Topography, slope exposure, soil type, and vegetative cover are examples of surface characteristics that create specific microclimates by altering solar radiation, temperature, wind, or humidity. By actively or passively selecting such microclimates, organisms can effectively reduce the overall climatic variation they encounter and enjoy more optimal conditions.

Changes in relative amount and distribution of north and south facing slopes due to mine related changes in topography could lead to significant wildlife impacts depending on site specific characteristics. South-facing slopes in winter range areas are important as resting and feeding areas for mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) because these slopes are generally not covered by deep snow. Any reduction in the acreages of south-facing slopes may have serious consequences in this time of stress. Reptiles may also be more abundant on south-facing slopes, particularly where there is a significant temperature difference between such areas and the adjacent north-facing slopes. If the area is a year-round or summer big game range, reduction in the number of south-facing slopes relative to others would probably not have as adverse an impact and may even benefit the animals by providing more surface area of slopes that are cool during the summer.

Natural topographic features such as caves, rough breaks, cliff faces, hummocks, hills, valleys, and canyons are extremely important to various wildlife groups, particularly during inclement weather. Hills and escarpments provide important windbreaks for wildlife, particularly in the flat open areas common in the mining regions of the western United States. Cliffs provide shelter and protection for many raptor species. Rugged, inaccessible cliffs are often the only areas where some raptors can nest and rear young without frequent human harrassment. Increased topographic variations, including highwalls, can be a positive byproduct of surface mining.

Vegetation

Effects on wildlife due to mining impacts on vegetation are attributable to two main processes: (1) complete removal or destruction of vegetation; and (2) establishment of new vegetatives types which differ from the original plant communities in species composition, density, vertical structure, diversity, and other important habitat qualities. The first occurs throughout the mine activity sequence until disturbance of new areas ceases. The second occurs whenever the planted or natural vegetative growth on disturbed areas is discernibly different from that on undisturbed sites.

Most habitat loss in a given region, at least during the life of a mining operation, is caused by the direct physical removal of the original vegetation. The impacts of this vegetative destruction on wildlife can be summarized as follows:

1. Destruction of the food source upon which primary consumer wildlife groups depend;
2. Destruction of cover upon which all wildlife species depend;
3. Displacement of mobile wildlife species;
4. Direct mortality of nonmobile species;

5. Overcrowding and increased competition for resources on adjacent areas;
6. Decrease in nutrient and energy flow to adjacent areas; and
7. Increase in wind and water erosion, thereby increasing turbidity and changing chemical composition of water supplies.

Loss or modification of habitat types that are widely distributed throughout the mining region generally has fewer ramifications on wildlife than does removal of localized or unusually productive habitats such as wetlands, riparian zones, and wooded stands in otherwise open terrain. It is generally in such areas of unusual or unique habitats that threatened or endangered animal species might be affected, a loss for which there is no compensation.

Activities which do not remove the vegetation but modify plant species composition, density, or structure will also affect wildlife. Examples include clearing tall trees for electrical transmission line rights-of-way, dewatering of streams or seeps resulting in modification of riparian habitats, fires, and chemical leaks and spills.

In addition to the loss of primary production which adversely affects local herbivore populations, the loss of small mammals and reptiles on these same areas constitutes a reduction in available food for predators. Because most large predators are wide ranging, it is difficult to assess how removal of a portion of their hunting range may affect them. If predators are food-limited or require a prey base within a given distance from breeding areas, however, a reduction in predator numbers proportionate to the reduction in their food supply could be reasonably expected.

During vegetation removal small animals of poor mobility are killed. More mobile animals escape, and are displaced into nearby areas. Depending upon the specific situation, competition may be severe or practically nonexistent. For example, if an adjoining deer herd has been maintained below carrying capacity by sport hunting, little food competition might result from influx of animals caused by the initial mine disturbance. Conversely, the impact on a food-limited herd could be severe until reclamation of the area was accomplished. For animals having brief longevity and high "r", population adjustments should rapidly occur to relieve competition. Most birds, because of their territorial behavior, will not allow the settling of displaced birds in saturated habitats, thereby eliminating potential food and space competition during breeding periods with the excess birds contributing to the "floating" component (which has a much higher mortality rate) of the population. This also would be true of some mammalian predators. Competition between displaced animals and permanent residents in the receiving area could be severe among species that have longer lifespans or specialized habitat requirements. The population adjustment period could be prolonged, with a net decrease in population size. Increased competition, both interspecific and intraspecific, due to the initial reduction of carrying capacity probably could also result in physiological stress which, in itself, could lead to direct mortality, emigration from the area, lowered reproduction, or behavioral aberrations such as cannibalism and offspring abandonment.

Energy mining, and surface mining in particular, also results in changes in wildlife community structure and consequently changes in functional relationships. Succession proceeds and results in new vegetative associations and hence new wildlife populations. In terrestrial systems, natural successional changes on mined land have been documented as following the general pattern for the region involved (Graham 1947, Bramble and Ashley 1955, Bauer 1973). Community dominance in the eastern United States, for example, typically changes from annual-perennial weeds, to grasses, to shrubs, to trees. The time frame varies depending upon site, climate, substrate, and seed sources, but typically shrubs are present by 10 years and trees by 20 years. Of course, wildlife populations will flux with these vegetation changes. Alterations in these successional patterns will be influenced by the reclamation practices and mining activities involved.

The avian community has been the most intensively studied wildlife segment. A hypothetical pattern for reclamation succession in West Virginia was described by Whitmore (1978). He suggested that as mining begins there is a dramatic decrease in avian diversity as lands are cleared and coal is extracted; perhaps a few bird species occupy the active mine area, but it is unlikely that they will nest. Following mine closure and the implementation of reclamation procedures, the number of breeding species increases to 4–6 and remains at that number as long as the land stays in the grassland stage. About 7 years after mine closure, shrubs become large enough for bird use and there is a marked increase in the number of species and the evenness of the distribution of each species in the total avian community. Another sharp increase to 14–15 species occurs about 10 years later when trees become large enough for bird use. Karr (1968), Chapman et al. (1978), and Curtis et al. (1978) noted similar patterns of avian succession; postmining bird diversity increases as the amount of vegetation present in the ground and shrub strata increases. Later, canopy closure results in a decrease in diversity (Chapman et al. 1978, Crawford et al. 1978).

Postmining diversity depends on the success of reclamation, the type of management involved, and on the presence of new habitat features created by mining. Crawford et al. (1978) reported lower diversity on reclaimed areas. Karr (1968) reported higher diversity on reclaimed areas than on adjacent unmined areas and attributed the increase to the presence of ponds created during mining. For wintering bird populations in northern Alabama, diversity and abundance on orphaned mines were similar to corresponding non-mine successional stages (Terrel and French 1976). The conclusion is that it is possible to attain equal or higher avian diversity after mining. An important corollary is that it is also possible to maintain mined areas at a certain successional stage, sacrificing diversity perhaps for the benefit of certain species. Whitmore (1978) and Allaire (1978a) both noted this potential, especially in relation to increasing populations of formerly uncommon grassland species in West Virginia. Unfortunately, similar data are not generally available for semiarid or arid regions but the same principles should be applicable.

The impact of energy mining on mammals varies widely, as one would expect. Successional patterns dependent upon vegetation have been described (Riley 1954, Sly 1976). Forest or woodland dependent species are severely impacted by postmine reclamation to predominantly herbaceous vegetation; grassland species are only lightly affected (Van Waggoner 1978). Ecotonal inhabitants often proliferate after mining and reclamation in the eastern United States.

Land Use Practices

If energy mining is conducted in compliance with environmental regulations and steps are taken to prevent or mitigate direct impacts to legally protected or other unusually sensitive species, the greatest long term impacts will normally result from accompanying changes in land use practices. Land use practices are important both on the reclaimed mine site and in the surrounding area. Energy mining virtually always results in an initial community simplification that is eliminated through natural seral development unless periodic disturbance occurs. Present reclamation laws and economic policies will maintain much of the mined land in low diversity (but possibly high productivity) communities. Present mine reclamation laws stress: (1) returning the land to its highest previous economic use, (2) achieving high vegetative biomass soon after revegetation, (3) uniformity of topsoiling, (4) grading out arroyos and highwalls, (5) filling of ponds, and (6) agricultural land. All of these act to decrease potential habitat and community complexity. This need not be the case. Revegetation is the least expensive part of reclamation, absorbing perhaps 15 percent of the total cost. Significant changes in revegetation and mining techniques can be made with very little impact on total reclamation costs. A wide variety of practices, if permitted by law or exemption, can be applied singly or in combination to increase vegetative and land form diversity on reclaimed land. Some of these are:

1. Increase diversity in seed mix;
2. Leave small plots for natural seral development;
3. Sod native vegetation;
4. Grade to develop topographic variation;
5. Reestablish drainage patterns;
6. Leave islands free of grasses for shrub and tree planting;
7. Mulch with native range hay cut after seed maturity;
8. Use several seed mixes for varying sites, instead of a universal mix;
9. Leave water collecting depressions; these will initially be small potholes or marshes and ultimately mesic meadows or forest pockets;
10. Plant hedgerows through and shrubby borders around mines in areas of adequate rainfall;
11. Salvage and spread topsoil as quickly as possible after seed maturation for most species;
12. Transplant various age classes of trees and shrubs; and
13. Leave highwalls and spires for raptor nesting sites.

Although the changes in land use of reclaimed areas are commonly recognized as contributing to wildlife impacts, the extensive secondary land use changes due to ancillary human activities throughout the area surrounding a new mine will typically cause much more significant impacts. Most new mines in the western states are accompanied by substantial growth of local human communities. This growth typically leads to subdivision of local farms and ranches for low density housing developments (U.S. Bureau of Land Management 1978c). Thus, lands contributing to local wildlife populations become permanently removed even though the mined land itself will be eventually reclaimed to an economically beneficial use.

Even minor changes in the use of reclaimed land can adversely affect local wildlife. Where range and timber lands once supported livestock or agricultural croplands and wildlife, reclaimed areas are typically revegetated and managed to support more livestock and hence fewer species of wildlife. Generally, re-created habitats are characterized by their simplicity, leading to unstability of the wildlife populations utilizing them, e.g., the common practice of reclaiming mined lands to intensive agricultural uses in the Midwest Coal Region. In effect, this practice has essentially the same impacts on wildlife as did clearing of original woodlands for agricultural practices—of simplification, of monotypic dominance, and of susceptibility to relatively simple perturbations.

In the western states rehabilitation of lands for wildlife is commonly directed toward a few conspicuous and important plant species instead of the variety of native species occupying the site prior to mining. In the eastern United States mountain-top mining and subsequent reclamation often result in pasture monoculture. Thus, the less diverse vegetative communities on reclaimed lands may be designed to support selected wildlife populations but will seldom support the full range of native species until a high diversity of food and cover is achieved through natural succession.

The various successional stages are inhabited by different wildlife species, thus the effect of modifying the successional stage will be enhancement of habitat characteristics for some species and degradation of habitat characteristics for other species. Whether the overall effects will be positive or negative depends on site-specific characteristics and the objectives of wildlife management for the area. For example, cutting a path through a spruce-fir forest might allow deciduous shrubs to establish in the absence of spruce-fir overstory, thereby providing additional forage for elk, mule deer, and bear (*Ursus* spp.), but at the same time possibly reducing population of birds that require a dense forest canopy. However, destruction of riparian habitat through aquifer disruption would probably always be considered a negative impact because species from adjoining areas that rely on the riparian areas for some life requirement would also be affected.

Wildlife species can be beneficially affected by changes in vegetation if important habitat types that had previously been in short supply are increased through reclamation. When evaluating this type of impact, a wildlife manager must consider the importance of benefited species relative to species which are likely to be adversely affected by the change. The manager must consider many minor technical details in his deliberations. For example, the methods of replacing topsoil are dictated by both land use objectives and the soil type involved. Uniform spreading of topsoil would allow maximum vegetative production. Such production would be to the landowner's benefit in most cases—providing more return from forestry, livestock, or farming. Total biomass of wildlife might also be maximized, but at the price of lower diversity. The objective of wildlife managers must be clearly defined and translated into engineering terms for application. Well planned reclamation toward a wildlife postmining land use could easily increase wildlife richness and biomass through the establishment of a more diverse vegetation and land form.

Solid Waste Pollutants

Disposal of waste materials is seldom a significant problem as long as the effects of such disposal are limited to the mine site itself and do not persist beyond the life of the mine. Coal mining conducted in compliance with current regulations rarely results in waste disposal problems, but the same is not true of uranium milling and oil shale processing. The sheer volume and adverse chemical characteristics of mill tailings and process wastes render them likely sources for eventual contamination of local ecosystems.

Virtually no literature is available on the population impacts of sublethal levels of increased radioactivity, heavy metals, or changes in nutrition due to plant substrates. Plants grown on coal mine spoils can be toxic in metals such as manganese, aluminum, zinc, and copper but low in phosphorus and potassium (Haynes and Klimstra 1975). Such potential elemental toxicities, deficiencies, or imbalances would vary widely depending upon the chemical-physical nature of the overburden, availability of water for leaching, selective overburden handling practices, and plant species used in revegetation. Greater potential for problems exists in regions where the overburden is acidic rather than basic. A high level of revegetative success could be achieved and the area would still remain unsuitable for a healthy wildlife community. This phenomenon has been little considered in mine and reclamation planning.

In addition to the threat of accidental discharges into local drainages, tailings ponds may be sufficiently toxic to cause direct mortality of visiting waterfowl, other birds, and mammals using the site for water. In most cases, however, tailings ponds or waste dumps can be fenced to minimize impacts to large wildlife species, but avian losses may still occur.

Fires

Most mining operations are well equipped for fire prevention and control; thus, fire-related impacts to wildlife are normally rare and accidental in nature. The most likely sources of fires will be trash burning sites, access roads, and local railroads. Where uncontrolled fires do occur they obviously cause major impacts to wildlife and vegetation, but the rarity of such events renders fire a relatively minor impact mechanism to wildlife. Mines should be ringed with firebreaks in areas of high fire hazard.

Direct Effects on Wildlife

Mining and related activities can have three types of direct effects on wildlife: (1) changes in animal density and species diversity in wildlife communities; (2) changes in the behavior of wildlife species; and (3) increases in wildlife mortality.

Allaire (1978b) gives one of the few documented examples of a community response to disturbance. He noted a 39 percent decrease in density, a decrease in the diversity index, and a slight increase in the number of species present in the breeding avifauna in deciduous forests immediately adjacent to an active coal mine in Kentucky. These changes were related to noise, ground shock, and dust clouds produced by blasting and appeared to be restricted spatially to a 328 ft (100 m) area adjacent to the pit and temporally to the duration of disturbance.

Potential effects of mining on wildlife also include behavioral changes, interference with communication (particularly for species which rely heavily on vocal communication), and physiological stress (Moore and Mills 1977, Allaire 1978b, Ames 1978, Busnel 1978). Physiological responses which affect growth and reproduction in domestic sheep have been correlated with noise alone (Ames 1978).

However, most of the potential effects on wildlife could be expected to result from combinations of several disturbance mechanisms.

Several authors point out that wildlife adjusts to increased disturbance levels, especially noise, over a period of time. Busnel (1978) indicated that a panic reaction can be produced by an abrupt intrusion of any kind, even acoustic, in the daily life of most vertebrate species, but if other senses are not stimulated most species quickly learn to ignore the noise source. Certainly, the severity of any potential disturbance depends on the nature of the disturbance, its intensity and duration, and on the sensitivity of the species involved. However, personal observations (Terrel) of wildlife at several Wyoming mine sites indicate that at least some species do, in fact, become habituated to mining disturbances. Those species noted thriving within and/or closely adjacent to active mining-reclamation activities include pronghorn antelope (*Antilocapra americana*), mule deer, various waterfowl species, various lagomorph species, sage grouse (*Centrocercus urophasianus*), red-tailed hawks (*Buteo jamaicensis*), and great-horned owls (*Bubo virginianus*). In northwestern Colorado, overwintering herds of elk have been observed feeding and resting on revegetated spoils very close to dragline and coal haulage operations. General observations indicate rapid habituation to the mining process if actual physical harm is otherwise absent. Since hunting is usually prohibited around mine sites, the nearby surrounding undisturbed or reclaimed lands often become sanctuaries. Influxes of big game into mining areas have been noted during hunting seasons (Terrel, personal records).

The behavioral plasticity or adaptability of most wildlife species is not well known. Raptor nests and grouse leks have been successfully moved, but apparently not more than a few hundred feet. With successive moves over time and by physically creating suitable nest sites, it may be possible to salvage important raptor nests from advancing mines. Wildlife managers should develop imaginative experiments to determine and then take advantage of any behavioral adaptabilities of important wildlife species. Some examples of imaginative management ideas for threatened and endangered birds are described in Temple (1978).

Direct mortality of wildlife due to energy mining activities is expressed as a standard expectation in most environmental analyses of proposed mining impacts in the West. However, the quantification of direct losses due to such things as vehicle collisions, increased legal and illegal hunting, wanton destruction and predation by domestic pets is rare to nonexistent.

Any human population increase is accompanied by additional hunting/fishing pressure, but the decided preference of mining personnel for these forms of outdoor recreation activities causes an additional increase beyond what would normally be expected for that incremental increase in population. In the Gillette, Wyoming area, for example, the mean number of recreation days per day of hunting season increased over 240 percent from 1971 to 1977 for antelope and by 143 percent for mule deer hunting (compiled from 1979 Wyoming Game and Fish Department records). During this same period, the human population increased by only 112 percent for Gillette County (U.S. Bureau of Land Management 1978c).

Poaching is the single most destructive activity, according to many wildlife managers and mining industry personnel. Big game animals are particularly affected because of their size and visibility. Numerous sources report incidents of mine workers shooting deer indiscriminately en route to and from work on a daily basis (Colorado Division of Wildlife, personal communication). The problem is compounded in areas where shift changes coincide with feeding periods (e.g., dusk and dawn) and access roads cross or come close to migration routes. The relationship of the mining work force to poaching rates has been clearly demonstrated at a mine in northwestern Colorado. At the Redstone Mine in Pitkin County the severity of the problem prompted the county commissioners to require the mine operator to initiate mandatory busing of employees from local communities in 1974. The incidence of poaching dropped dramatically immediately after busing began (Colorado Division of Wildlife, personal communication). Occidental Petroleum Company prepared a wildlife management plan prior to developing an oil shale lease in Rio Blanco County, Colorado, and concluded the potential for mule deer road kills and poaching by future employees was large enough to warrant providing bus transportation for employees.

Other examples of the magnitude of increased human population impacts include: (1) in southeastern Montana, researchers found that of six mortalities of marked mule deer, two were caused by illegal hunting (Biggins 1976); (2) a 10 percent increase in illegal hunting was projected in the west-central Colorado coal development region (U.S. Bureau of Land Management 1978b); and (3) the total fines levied annually for hunting violations in Campbell County, Wyoming, a region of active mining increased 545 percent from 1972 to 1977 (Wyoming Game and Fish Department 1972-1977).

Road kills may be a major contributor to direct mortality. These kills may be either deliberate or unintentional. In at least one mine area in northwestern Colorado, eyewitness reports of deliberate destruction of big game by haul truck operators have been compiled by Colorado Division of Wildlife personnel. Most wildlife losses, however, involve involuntary collisions with vehicles driven by mine workers on access roads (Colorado Division of Wildlife, personal communication). As in the case of poaching, these impacts are aggravated if access roads cross migration routes or shift changes coincide with big game feeding periods. An additional increase in road kills associated with mine related population growth may be assumed on frequently traveled roads in the vicinity of local communities. In some areas road kills may have significant local impact. For example, four of six mortalities of marked animals were caused by vehicles in a southeastern Montana study (Biggins 1976).

Management controls could include seeding roadsides to unpalatable species and seeding food "plots" away from the roads, which would lessen both car–animal collisions and poaching. In critical areas, employees could be bused to work or prevented from carrying firearms in vehicles that enter mine property.

An increased number of domestic animals, especially dogs and cats, commonly accompanies human community growth and can result in direct adverse effects on wildlife. Packs of free-roaming dogs have been known to attack and kill deer and other animals, a particularly serious impact because weaker individuals, including does and fawns, are the primary victims (Houston 1968). Packs of dogs eliminated a herd of 200 to 300 deer over a 4 to 5 year period in a nonmining community near Vail, Colorado, and over 170 deer were killed in the vicinity of Aspen, Colorado during a single year in which the legal hunting limit was only 53 deer (Colorado Division of Wildlife, personal communication). Other negative effects that may occur include predation on birds and small rodents by cats, and increased poisoning and shooting of coyotes or other animals that are perceived to threaten domestic animals (Howe 1973).

Human Presence Effects

The primary factors determining the type and magnitude of "people" impacts are employment levels and the corresponding population influx and the stability of the work force through time. The severity of impacts is directly proportional to the total number of imported (nonlocal) employees, the size of the construction force, rates of increase or decline in employment levels, and the land use and recreation demands specific to the incomes, age patterns, and other characteristics of energy mining related populations. Impacts are frequently compounded by the development of a number of energy projects simultaneously within a given area, so that the effects of any individual operation cannot be considered in isolation but must be examined in the broader context of cumulative regional development. This is not without its positive aspects since the sudden swings in construction employment can be significantly reduced if the construction schedules are staggered to allow the construction work force to rotate among different projects.

Project employment levels. Typical employment levels for various types of energy operations are summarized in Table 9. A considerable difference exists between construction and permanent employment levels for coal mining as opposed to operations involving on-site conversion (e.g., power plants, coal gasification).

Local vs. nonlocal employment. The relative proportion of local versus nonlocal employment is important because it determines the energy-related population influx and severity of population-related impacts, including those on fish and wildlife. Labor origin studies of the Four Corners and Old West Regions indicate that in the Four Corners area (Colorado, New Mexico, Arizona, and Utah) 46 percent of the construction workers were hired locally, 42 percent were hired from other parts of the Four Corners area, 2 percent were hired from Wyoming and other Old West Region states (Montana, North Dakota, South Dakota, and Nebraska), and 10 percent came from other parts of the country. Labor supply patterns in the Old West Region showed lower local employment (34 percent) and more reliance on immigration of workers from areas beyond the Rocky Mountain States (31 percent). To some extent, these figures reflect the higher levels of energy development, especially the number of labor-intensive construction projects in the Old West Region (particularly Wyoming) which tend to deplete the available local labor supply. Although the percentage of local permanent employment is typically higher (around 70 percent), that figure reflects a certain portion of construction employment absorbed into the permanent work force (Mountain West Research, Inc. 1975).

Total population increase. It is more difficult to summarize the "typical" total population influx because the population increase associated with any particular project is directly related to labor requirements, local labor supply, recruitment policies, and the number of dependents (household size) for imported workers.

Table 9. Manpower requirements summary by type of project and region.

Type of project/region	Production level	Employment	
		Construction	Permanent
Surface coal mining			
Eastern U.S.	5.0 million tons/ year (MTPY)[b]	na[a]	178[b]
Interior	5.0 MTPY[b]	na	na
N. Great Plains	10.0 MTPY[c]	450[c]	290[c]
Southwest	5.0 MTPY[b]	250[d]	123[b]
Underground coal mining (48′ Seam)	1.0 MTPY[b]	na	257[b]
	2.0 MTPY[b]	na	464[b]
	3.2 MTPY[b]	na	688[b]
Coal gasification			
High BTU	250 million std. cubic ft/day (MSCFD)[e]	3,000[e]	700[e]
Low BTU	250 MSCFD[e]	3,200[e]	650[e]
Coal liquefaction	45,000 barrels/day[e]	758[e]	593[e]
Surface oil shale conversion	45,000 barrels/day[e]	1,470[e]	30[e]
In situ oil shale conversion	na	1,827[b]	1,158[b]
Uranium solution mining	160,000 lbs. yellowcake/month[f]	na	160[f]
Tar sands	na	na	1,500[g]

[a] na = not available
[b] Argonne National Laboratory 1975
[c] Atlantic Richfield Company 1978
[d] Abt Associates estimate
[e] U.S. Department of Energy 1978
[f] Engineering/Mining Journal 1978
[g] Intercontinental Engineering of Alberta, Ltd. 1973

The relationship between basic (mining) employment, secondary (service) employment, and total population increase is typically expressed by a series of *multipliers,* incorporating local socioeconomic data and work force characteristics (e.g., household size). Representative total population increase/permanent mining employment relationships in the western United States range from 4.9 to 6.7 persons for each basic employee, or a total population increase of 490 to 670 people for every 100 imported permanent employees (Abt Associates estimates).

A total population increase of 228 people can be expected for every 100 imported construction workers (Mountain West Research, Inc. 1975). This number typically includes 25 single workers, 26 married workers without families, 49 married with families present, 49 spouses, and 79 children. Of the children, 57 or 72 percent are under 11 years of age. Average family size is 3.97 persons for local workers, and 3.78 persons for nonlocal employees with families. The lower total increase associated with the construction work force reflects a higher proportion of single workers or married workers whose dependents live elsewhere, than among permanent employees.

In summary, the implication for local planners and wildlife managers based on historic data from existing impact areas is that the severity of social impacts increases geometrically with the total population increase, particularly during the construction period. Relevant demographic characteristics of energy-related populations which can influence the severity of these effects are discussed below.

Relevant demographic characteristics. The demographic characteristics of incoming energy mining related populations with the greatest relevance in determining wildlife impacts include disposable income, family size, age structure, and recreation preferences. These statements are based on a knowledge of the current literature and professional experience assessing the impacts of mining-related populations on rural areas within the western United States. The general characteristics of these population groups and their implications for wildlife are summarized below:

1. Construction and operations workers exhibit markedly higher levels of disposable income than existing residents, which coupled with low labor force participation rates (secondary employment by spouses and dependents), indicates higher recreational demand, particularly for outdoor recreation.
2. The preponderance of workers in the 26–35 year age group, including the majority with young families, indicates higher recreational demand, particularly increased hunting and fishing pressure.
3. Energy-related workers have a marked preference for use of recreational vehicles (campers, four-wheel drive trucks, boats, snowmobiles, and motorcycles). The impacts of these types of recreation on wildlife, particularly the use of off-road vehicles, are particularly severe.

This combination of traits collectively indicates that it can be expected that the effects of energy-related population growth will exceed the level of wildlife impacts associated with resident populations. Additional detail on these demographic characteristics is presented below. Comparisons are made between energy-related workers moving into a community (construction and operations work-force), other new residents including service and secondary employees in jobs created by energy development and their dependents ("other newcomers"), and existing ("long-time") residents. Emphasis is placed on the construction workforce because they typically represent the most significant population increase and exhibit recreational user characteristics most detrimental to wildlife values.

Income and labor force participation rates. Probably the most significant difference among energy workers, indirect workers (service employment), and long-time residents is in personal income and labor force participation rates. Construction workers in the Old West Regional Commission survey communities had average salaries of $17,689. Long-time residents had average salaries of $13,913, and indirect workers had average salaries of $15,300 (Mountain West Research, Inc. 1975). Thus, the average salaries of construction workers were 30 percent higher than long-time residents and 16 percent higher than indirect workers. Permanent employees' wages and salaries tend to be slightly lower than those of construction workers but also significantly higher than the income of other residents. Participation rates were 12 percent for construction workers, 25.3 percent for indirect workers and 32.8 percent for long-time residents. Therefore, labor force participation rates were inversely proportional to income, indicating that relatively few energy workers' spouses were employed and had more free time while long-time residents had the greatest reliance on two incomes.

The age distribution of a typical work force for the Decker Coal Mine in Montana for nonlocal workers is 20 percent in the 18–25 age bracket, 48.6 percent in the 26–35 age bracket, 8.6 percent in the 36–45 age bracket, and 22.9 percent over 45 years of age. The percentages are similar for the local workers (Wieland et al. 1977).

Housing and land use requirements. Housing characteristics for coal mining communities are estimated for construction workers, permanent workers, and indirect workers. Of construction workers, 15 percent own single-family homes, 10 percent rent apartments, 60 percent own mobile homes, and 15 percent have other types of housing. Of permanent workers, 60 percent own single-family homes, 20 percent rent apartments, 15 percent own mobile homes and 5 percent have other housing. Finally, of indirect workers, 61 percent own single-family homes, 12 percent rent apartments, 20 percent own mobile homes, and 2 percent have other housing (U.S. Bureau of Land Management 1978d).

While all resident groups prefer single-family dwellings, a large number of construction workers and other newcomers are forced to live in other housing types, primarily mobile homes, because of shortages of single-family homes. If market conditions were more responsive to this housing demand, much larger amounts of land would be converted to urban uses, with corresponding reductions in wildlife habitat.

The total land area required to accommodate population increases far exceeds residential areas alone. An energy operation results in land consumption (and accompanying habitat destruction) for residential, commercial, and community infrastructure (public facilities and services) as well as the energy facility itself. Table 10 gives typical land use factors for these various categories which can be combined to indicate total land use requirements.

Recreation Characteristics. Surveys of construction and permanent workers indicate their most popular recreational activities are fishing, hunting, camping, picnicking, and sightseeing, with lower priority given to indoor activities and spectator sports.

Although little specific data exists on the recreation vehicle (RV) ownership characteristics of energy workers, some indications can be derived from comparing population and vehicle registration trends in heavily energy impacted areas such as northwestern Colorado. Moffat and Routt counties have been the site of intensive coal development over the last 5 years as reflected by population growth rates of 47 percent and 19 percent, respectively, between 1974 and 1978 (derived from Colorado Division of Planning data). During that same period registrations for recreational trucks increased over 550 percent in Moffat County and 383 percent in Routt County (Colorado Department of Motor Vehicle records).

While further research is required to establish more precise relationships between ownership of recreational vehicles (particulary off-road RVs) and energy workers as opposed to RV ownership among other population groups, these data indicate a positive correlation between these variables.

Off-road vehicles, particularly snowmobiles, can have significant impacts since their use requires the development of various kinds of trails which destroy habitat and can disrupt migration routes, critical range, and breeding areas. Traffic on the trails is additionally disruptive, at least initially, because of noise and the presence of humans. Direct mortality can result from stress to animals already experiencing high levels of stress associated with winter conditions. Snowmobiles have equally severe impacts of rodents and other subnivean life forms, with indirect effects on larger predators who are dependent on them for a major portion of their food supply. In addition, snowmobiles may be used to provide access to hunting and fishing areas not previously utilized (Baldwin 1968).

Table 10. Selected community development land use requirements (U.S. Department of Energy 1978).

Category	Lane use requirement
Residential	Single-family homes = 3 units per acre Mobile homes = 5 units per acre Multifamily homes = 10 units per acre Total land requirement = single family + mobile + multifamily units
Commercial	Retail, service, and office building space based on total sales, employment, receipts by type and other factors Parking space = total building space × 1.875 Other land requirement = (building space + parking space) × 0.25 Total land requirement = building space + parking space + other land
Industrial	Industrial building space = 550 sq. ft. per employee Parking space = 260 sq. ft. per employee + parking space) × 0.2 Total land requirement = building space + parking space + other land
Parks and open space	Playgrounds = total population × 1.8 acres per 1,000 population Neighborhood parks = total population × 3.0 acres per 1,000 population Community open space = total population × 3.7 acres per 1,000 population Total land requirement = playgrounds + neighborhood parks + open space

Summary

Many potential impacts relating to energy mining exist, from air, soil, and water pollution to land form, vegetation, and land use changes. Through sound resource and technological planning, these can be and are being minimized. The remaining major impacts that are not modifiable simply through technological controls can be reduced to two general categories: (1) regional human population changes and (2) postmining land use.

5. The Wildlife Manager—Management Opportunities and Decisions or "Which Way to Turn"

Introduction

We have provided a sketch of the energy mining scene in North America in the previous sections by scanning the magnitude and type of potential perturbations to wildlife resources. The logical questions that follow are "What can or should we do to insure a minimum impact on our wildlife resources?" And, "How can I best allocate my manpower and budget to solve the remaining major energy development problems and maximize benefits for wildlife resources?" Or just plain "Which way should I turn?"

It appears that there are three major audiences, or routes of influence, for wildlife managers: *governmental decision and planning processes,* the *mining industry,* and the *interested public.* There are many modes of influence for each of these audiences but there are three that may be the most effective, serving each of the three audiences in turn with only minor modifications. These are, for wildlife managers within their respective jurisdictions to: (1) develop a preferred sequence based upon regional wildlife priorities for ranking lands within each region from unsuitable for mining to most suitable for mining; (2) establish and promote stipulations and mitigation requirements to insure maximum protection of wildlife resources during mining; and (3) establish the postmining land use objectives and strategies preferred from a fish and wildlife resource perspective. In all cases the provincial or state wildlife resource agency should be involved where resident species are involved. Industry, Indians and various federal agencies will have to participate when management responsibilities dictate. Ideally, regional priorities for wildlife habitat should be a joint product of all managers.

Ranking of Lands for Suitability and Unsuitability for Mining Based Upon Regional Wildlife Priorities

Surface areas overlying energy mineral resource deposits should be categorized with respect to wildlife priorities within a continuum ranging from unsuitable for mining to preferred for mining. Within the preferred segment of the continuum, each parcel of land should be designated with a preferred priority ranking. In other words, a sequence for new mining, and therefore reclamation, should be established for the lands most acceptable for mining. In order to do this, states and provinces will have to identify the sensitive and important species, populations, and communities of wildlife and their habitats. They will have to be aware of current land uses and rates of land use change and the correlated impacts on wildlife habitats. Managers must establish priorities of wildlife species, populations, communities and their habitats and document their values in biological, social and economic terms.

This viewpoint is idealistic, and to accomplish such a task will require the utmost in cooperation among state or provincial and federal or dominion agencies and the general public. It is recognized that wildlife perspectives cannot always be the overriding consideration in designating each parcel of land acceptable or unsuitable for mining. Because of extremely strong and justifiable economic and social incentives for mining in areas that would be undesirable from the standpoint of wildlife resources, the former considerations may well win out. The important issue, however, is that wildlife resource managers need to develop an approach that insures that wildlife resources are given full and equal consideration in an overall prioritization for mining processes. This means being "up front" with established priorities rather than coming in from behind to review industry or other developmental agency plans.

Wildlife managers, in order to be cost effective in the designation of lands that are unsuitable and those lands that are preferable for energy mining, will have to apply exclusionary criteria or data avoidance techniques that will block out portions of the states or other geographically defined areas that would not have any high probability for mining for reasons other than wildlife or environmental concerns. Such reasons could include provincial or national parks and wildlife refuges that may be excluded by law; and, of course, areas where there are no mineral resources, or extremely poor quality resources from a resource recovery standpoint. In this way, manpower and funding, perennially limited as an "occupational disease," can be allocated to only those geographic areas where they can be used most effectively in the influencing of land use decisions to be of maximum benefit to wildlife resources.

Criteria for establishing areas unsuitable for mining on both public and private lands in the United States have been called for in the Surface Mining Control and Reclamation Act. Specific criteria for federal coal resources were established by the Secretary of the Interior in 1978 (U.S. Bureau of Land Management 1978a). Of the 24 criteria, 10 are of particular importance to wildlife managers. These are criteria entitled Lands Used for Scientific Studies, Migratory Birds, State Resident Fish and Wildlife, Wetlands, Federally Listed Endangered Species, State Listed Endangered Species, Bald and Golden Eagle Nests, Bald and Golden Eagle Roost and Concentration Areas, Falcon Cliff Nesting Sites, and Reclaimability. Such criteria could also be established for non-federal coal areas by state agency initiative in the United States, and may be an effective "influencer" in provincial land use decisions. The application of these criteria in the United States is currently through the Bureau of Land Management land use planning process for all federal coal resource areas controlled by the United States government. These criteria not only satisfy the federal land planning process, but can be used to serve industry in its preliminary planning for mine siting well in advance of the large monetary investments in a development plan. Many of the same criteria can be used for developing a prioritization or sequencing preference for mining. For example, information related to the reclaimability of a piece of land for wildlife habitat would be of particular importance in establishing the preferred areas for mining. This is because lands with degraded wildlife habitats that could be improved through mining and subsequent reclamation should be ranked higher for mining from a wildlife perspective than lands without that potential.

By providing early recommendations to industry and the land management agencies, we can insure that fish and wildlife resources are given consideration well in advance of developmental actions, and therefore improve the probability of their being given adequate consideration in the overall trade-off processes that occur both within industry and governmental agencies.

Such procedures can also be used to elicit public support for particular resource areas. For lands that have a high wildlife priority but are nonetheless selected for mining, wildlife managers should have carefully developed "trade-off plans" that include stipulations for maximum protection of wildlife during mining, reclamation strategy preferences, offsite mitigation, and/or habitat enhancement requirements. Through the use of nationwide geographic information systems and associated data bases, compatibilities of proposed mining developments with wildlife resources can be made in an open, public participation forum. There is an urgent need, however, for wildlife resource specialists to take immediate steps to define the minimum data requirements acceptable for application of the unsuitability criteria and establish the preferred inventory techniques and processes.

Such designations as "unsuitable" and "preferred" and the continuum in between will require wildlife managers to take firm stands on priorities for species, priorities for geographic areas, and the priorities of overall environmental concerns as compared to those that are simply related to species of high public concern to a particular state. They will require fairly rigid structuring of data acquisition and analyses and may cut into nonessential research and inventory programs. Errors in judgment can and will be made. However, in the long run we feel that wildlife resources can only gain from the establishment of a continuum or prioritization such as that we have proposed.

Establish and Promote Stipulations and Mitigation Requirements to Insure Maximum Protection of Wildlife Resources During Mining

Stipulations and mitigation measures were mentioned in earlier sections of this paper. It is necessary for wildlife managers to examine each ongoing mining operation and all proposed operations to insure that an adequate balance of stipulation and mitigation measures have been built into each project. Technical advice, consultation between wildlife managers, and consulting with the mining industry on the correct application and execution of such stipulations will be required. Manpower and monetary resources will be needed by wildlife managers in state, provincial, and federal organizations to adequately monitor and enforce these stipulations and mitigation requirements. Additional resources will likely be required but need not come from general taxes or the sportsman as has usually been the case. One new source of such funds could be a share of mineral severance taxes that are collected by each state. The Surface Mining Control and Reclamation Act calls for the establishment of research institutes and for reclamation of abandoned mined lands with federal funding available. Another source, or perhaps a cofunding source, would be directly from industry itself. Specialized wildlife tactical teams supported by such funds could be established to enforce stipulation and mitigation rules related to wildlife resources. The teams could also be advocates to the industry and surrounding communities for the environmental message, especially from the perspective that the impact of social activities in the form of illegal hunting and harrassment is an additive factor that negatively affects wildlife resources.

The specific stipulations and mitigation measures that are established for each mine must be formulated after careful consideration of what is practical for each individual situation. Allocation of resources from agencies and organizations involved in wildlife management will be one of the difficult decisions facing managers in the coming years. If the magnitude of mining will be significant within a state or province, then trade offs will have to be made. The development of funding programs during the next 2 years will not be any too soon to prepare for the increased developmental activities that are anticipated for the 1980s.

Indian leaders have a unique opportunity to protect and enhance wildlife values through lease provisions and tribal agreements with energy developers. Wildlife management goals can be included in primary criteria for approving prospective development plans, an approach already used by the Colville Tribe in selecting Amax Inc. to develop copper and molybdenum deposits on their reservation in Washington.

The enactment of new regulations will not automatically eliminate all impact of energy mining on wildlife, of course. Many of the short and long term effects on wildlife by massive surface disturbance, human travel and presence in previously remote areas, development of human community support bases with consequent usurpation of wildlife habitat, and accidents will continue to be important impacts. But protective and mitigative measures to prevent or minimize entry of pollutants into air and water, to protect valuable soil resources for future revegetation use, and to establish long-term land use objectives and verify that they are being implemented even during the life of operation, will help reduce some of the more significant short and long term effects.

Establishing Post-Mining Land Use Objectives and Strategies Preferred from a Wildlife Resource Perspective

The third mode of influence wildlife managers can use for effective input into mining related decisions is that of establishing specific objectives for postmining wildlife land uses and the strategies that will be required to reach those objectives.

Determination of postmining land uses is particularly critical for wildlife values on reservation lands. The premining tribal subsistence economy is often based on dryland grazing, which in many cases has led to a steady degradation of the soil and vegetation and loss of productivity because of overuse. The dependence of tribal members on grazing to maintain even a minimal standard of living has made efforts to improve grazing practices through herd reduction a virtual impossibility and source of bitter contention among tribal members and with federal agencies. Realization of significant royalties and other energy-development revenues may afford a unique opportunity for tribal managers to enhance productivity through selection of a more balanced range of uses, including wildlife, which could potentially provide a substantial food source for Indian subsistence hunters. It may be possible to retain other positive mining related effects, such as increased riparian areas created by mine drainage patterns. These beneficial uses will be possible only where deviation from existing land use patterns is acceptable to tribal members and all other involved parties.

The specifics may vary from Montana to Alabama or from Alberta to Arizona but the goal of obtaining a wildlife use in the postmining land use plan is the same. In the United States, the Office of Surface Mining Regulations (U.S. Office of Surface Mining 1978) call for the "Best Technology Currently Available" to be used in reclamation of coal surface mines. Managers need to insure that there is a synthesis of biological knowledge and the expertise available so that specific habitat requirements for species or groups of species that are a part of the postmining land use objective can be identified and quantified. These objectives and strategies for reclamation to a wildlife postmining land use must then be translated into engineering and "bulldozer" terms to insure that a strategy preferred for wildlife resources can be readily incorporated into a reclamation plan. As in the former modes, wildlife recommendations to the decision maker, public or private, may not always prevail. However, early development of such objectives and strategies for postmining land use options that either include wildlife or have wildlife as the major goal or input will improve the chance of wildlife receiving adequate consideration. One reason we believe that such opportunities exist is that most reclamation activities can be conducted at lower cost if wildlife habitat is the major objective instead of grazing or cropping land uses. It simply costs less to leave some high walls and rough landscape, or move less material.

If, however, the postmining land use will eventually be a center pivot irrigated alfalfa field or an industrial site, dollars and energy should not be expended on developing a 5-year interim land use of a native grass cover as is called for in some state regulations. By teaming up with industry and/or the land management agency and /or the landowner, wildlife managers can insure that islands of high quality, diversified habitat are established, particularly in regions of the continent where suitable rainfall and soil characteristics occur. Also, lands in some states and provinces may be acquired as gifts or at a bargain rate from mining companies that cannot or prefer not to provide the postmining management of those lands. These lands can be acquired for various wildlife related recreation activities including hunting, fishing, and natural history observation.

Postreclamation land management plans need review by wildlife managers to insure that management of reclaimed lands will not be detrimental to wildlife resources. Intensive grazing systems and monocultures are examples of uses that would result in continued fish and wildlife losses. Resources should be allocated to evaluate postmining land uses for wildlife and the various reclamation techniques used, and to continue to improve the state-of-the-art in reclamation specifically for beneficial wildlife impacts.

As discussed in earlier sections, the establishment of riparian areas, wetlands, and specialized habitats for threatened or endangered species or species of high value within a particular region may be products of mining activity. Effective planning can thus create opportunities for wildlife that would be difficult to accomplish in the absence of energy mining activities. The degree and intensity of an advocacy role played by state, provincial and federal wildlife managers, wildlife professionals within industry, and the interested public will greatly affect the gains that are made through reclamation of land mined each year in North America.

The establishment of such postmining reclamation objectives and strategies must relate to comprehensive plans developed by the state and provincial agencies for the species and habitats of animals with which they are concerned. Such comprehensive plans should also be established by federal agencies for species for which they have primary management responsibilities. Specific habitat and development procedures and postreclamation management preferences should be readily available to the mining industry. Experience suggests that industry is open and willing to cooperate with such efforts. They require that rules by established early so that industry can incorporate wildlife values early in their planning of the mine and mining activities.

Summary

Energy mining, although not affecting every state or province equally, will have major regional effects on land uses. The postmining land uses and the increase of public pressures on wildlife resources will be the primary impacting agents. By taking an active, positive role in governmental and industrial decision processes, wildlife managers can be effective by identifying lands suitable and unsuitable for mining, by establishing protective stipulations and mitigation requirements, and by promoting preferred wildlife related postmining land uses. These actions will maximize prevention of irreversible adverse impacts and maximize benefits to wildlife resources as positive approaches to the problems related to energy mining.

Credits and Paper Development Approach

This paper was developed by a team who have, for a number of years, been working on energy mining related impacts on fish and wildlife resources. Individuals from the mining industry, academia, government, and environmental consulting were represented on the team, thereby bringing a breadth of perspectives and experience to the task. The outline of the paper was formulated and revised during team workshops, after sections were prepared by individual team members in accordance with guidelines established at an initial workshop.

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Energy from Forests: Environmental and Wildlife Implications

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Introduction

The United States and Canada have the highest per capita energy consumption of the world, with about 2,700 gallons (10,200 l) of petroleum equivalents consumed per person per year (EOP 1977, CYB 1977). With fossil energy supplies being rapidly depleted and the continued heavy use of energy by North Americans, an urgent need exists for the development of new energy sources. No one technology will be satisfactory in supplying all the energy needs in the future. Wood and other forest products have been suggested as one technology that has the potential of providing an abundant source of fuel (Alich et al. 1976, Inman 1977, Howlett and Gamache 1977, Pecoraro et al. 1977).

In the recent history of North America, wood was the prime source of fuel. For example, as recently as 1850 in the United States, 91 percent of U.S. fuel was produced from wood biomass (EOP 1977). But at that time the U.S. population was only about one-tenth its present size and per capita energy consumption was only about one-fourth of present consumption. Today, wood supplies a mere 1 percent of U.S. and 4 percent of Canadian energy needs (USBC 1977, CYB 1977). In certain regions wood is an important fuel resource.

Our forest resources should be managed more effectively for energy conversion. Forest production has energy potential, but in making use of this resource for energy we must not adversely affect the use of forests for lumber, pulp, recreation, and must find ways to maintain the ecological stability that exists in these forests.

This report analyzes the feasibility of utilizing forests in North America as an energy source. The analysis focuses on three major aspects: (1) the technology of converting wood biomass to energy; (2) the potential of wood as a source of energy; and (3) the environmental implications of using forest products for energy.

Technologies for Wood Biomass Conversion

Several methods can be used to convert wood and forest wastes into high quality forms of energy. The five technologies that will be analyzed are: pyrolysis, gasification, charcoal production, methyl alcohol production, and electrical generation from direct combustion.

In pyrolysis, high temperature and high pressure are used for conversion of wood and wood wastes into various forms of fuel. Depending on the temperature and pressure conditions employed, the final products may be primarily oil, gas, or char (solid). Frequently some of the gas produced is recycled and used to dry the incoming wood.

The energy value of the final fuel products depends on the wood substrate and operating conditions of the pyrolytic equipment (Freeman 1973, Bliss and Blake

1977). Soft wood, for instance, produces energy products that have the following energy values per kilogram of product: oil, 5,494 kilocalories (kcal); gas, 2,775; and char, 7,200 (Tillman 1978).

To convert 1 metric ton of wood into oil by using pyrolytic equipment requires an input of 1.2 million kcal in addition to the wood itself that contains 4.7 million kcal (Table 1). The output in oil is 3.2 million kcal. The 72 percent net return in conversion if all products (oil, gas, and char) are included is considered a satisfactory return.

If wood is converted into methanol, the return is only 23 percent (Table 2). The inputs for this type of wood conversion are a high 4.4 million kcal, while the return in methanol is only 2.1 million kcal. Hence, much more energy is expended than is obtained in the methanol product. Adding the energy cost of the wood input of 4.2 million kcal lowers the net return to only 23 percent, a relatively poor return.

Wood and wood products can also be converted into charcoal, which when burned will produce about 7,500 kcal per kilogram, or a relatively high level of energy per kilogram of product. Charcoal is light in weight relative to its energy content because of its low moisture content, but is, however, bulky. Charcoal is clean burning, produces little sulfur, and burns primarily to CO_2, CO, and water.

Charcoal, however, is energy inefficient to produce. For example, to produce a kilogram of charcoal that contains 7,500 kcal, about 30,000 kcal of wood are processed. This means that about 4 kcal of wood must be processed to produce 1 kcal of charcoal.

Charcoal is produced by burning wood with a small input of oxygen. In the burning process heat and smoke are given off, and various turpines are volatilized.

Table 1. Energy budget for the pyrolytic conversion of 1 metric ton of wood (4.7 million kcal) into oil and other products.

	Quantities	Kcal
Inputs		
Electricity	11 kw	687,820
Fuel oil	485,750 kcal[a]	485,750
Machinery	25,910 kcal[a]	25,910
Total		1,199,580
Outputs from 1 metric ton wood feed[b]		
Pyrolytic oil	3,181,350 kcal	3,181,350
Pyrolytic gas[c]	126,940 kcal	126,940
Char	1,015,540 kcal	1,015,540
Total		4,313,830
Net Return		
From Pyrolytic products		3,114,250
Percentage	$\left(\frac{4{,}313{,}830 \text{ kcal}}{1{,}199{,}580 \text{ kcal} + 4{,}717{,}000[\text{wood input}]}\right)$	73%

[a]Assuming inputs per dry metric ton of wood are similar to pyrolization of urban wastes (data from Freeman [1973] and Vergara [1977]).
[b]Oven dry metric ton of wood (1 kg wood = 4,717 kcal). Moisture content of wood feed was assumed to be 50 percent.
[c]Gas = 283 kcal/ft³.

Table 2. Energy budget for conversion of 1 metric ton of wood (4.7 million kcal) into methanol (Bliss and Blake 1977).

	Quantities	Kcal
Inputs		
Gas	52,720 scf	3,532,380
Electricity	1.4 kw	888,600
Machinery[a]	25,910 kcal	25,910
Total		4,446,890
Output from 1 metric ton wood fuel		
Methanol	394 kg	2,138,600
Net Return		
From methanol		2,331,600
Percentage	$\left(\frac{2{,}138{,}600 \text{ kcal}}{4{,}446{,}890 \text{ kcal} + 4{,}717{,}000 \text{ kcal [wood input]}}\right)$	23%

[a]Machinery inputs assumed to be similar to those in Table 1.

If these turpines and other chemicals are collected, and used to produce turpentine and other industrial chemicals, then the relative energy efficiency of charcoal production can be improved.

Without collecting these chemicals and using normal processing techniques, the efficiency of converting wood to charcoal is only about 25 percent. Projections are that with technically improved equipment and including the collection of the chemical by-products, this efficiency could be increased to about 33 percent.

Another method of converting forest products into high quality energy is by burning and producing electrical power. In general, electrical power (energy) has several advantages: (1) electricity is high quality energy; (2) scattered wood biomass can be collected and converted in an electric power plant located adjacent to the combustible materials (forest biomass is heavy and bulky to transport); (3) once produced, electrical energy can be transported easily to the consumer; (4) wood is a relatively clean burning fuel and the residue ash is small or about 1 percent of the input wood; and (5) the ash contains large quantities of potassium, phosphorus, calcium, and other minerals that could be recycled as fertilizers and thereby reduce the energy expended for the fertilizer input in agriculture and forestry. A 100 megawatt (MW) power plant produces about 457×10^6 kilowatt hours (kwh) (393×10^9 kcal) (FPC 1970) annually and will supply electrical energy to a small town of about 50,000 (Kemp and Szego 1975). The prime disadvantage of electrical generation is the low (25 percent) efficiency conversion of fuelwood energy into electricity. With a total annual operating cost of 2.8 million kcal, the 100 MW plant will need to process about 1.57×10^{12} kcal of fuel wood annually (Table 3) to produce a net of 457×10^6kwh.

Commercial Use of Forests in the United States and Canada

As mentioned, firewood provides only about 1 percent of U.S. fuel needs while in Canada the percentage is estimated at less than 4 percent. The major use of the

Table 3. Estimated major inputs for electric power generation from a 100 MW power plant for one year requiring fuel from biomass of 1.57×10^{12} kcal (FPC 1970) assuming a net conversion efficiency of 25.[a] Note that a 25 percent net efficiency (393×10^9 kcal) includes electricity used in operating the plant.

Inputs	Quantities	Kcal (10^6)
Construction Quantities		
Steel, including equipment (35 year life)	130 t[b]	2,589
Concrete (35 year life)	76 t[b]	152
Manhours	21,600 hours[c]	——
Operation and Maintenance		
Electricity	40×10^6 kwh[d]	137,600[f]
Manhours	100,000 hours[e]	——
Total		2,841

[a]S. Linke, Cornell University, personal communication, 1977.
[b]FEA 1974. Figures linearly extrapolated from estimates of concrete and steel needed for plants of 700, 800, and 900 MW with 35 year life expectancy (FPC 1970).
[c]FEA 1974. (6.92 manhours/kw for construction + 0.63 manhours/kw for design) × (100 M plant size)/35 year life.
[d]Electricity used in plant = Gross − Net generated (Olmstead 1973, 1975).
[e]Olmstead 1975. Assuming 0.5 manhours/kw, 40 hr/week, 48 weeks/year.
[f]Excluded from total because this amount of electricity was accounted for in the net efficiency of electrical energy production.

forest resources in both countries is for lumber and pulpwood. Of the total biomass produced in the forests (2,300 Mt [million metric tons]) only about 410 Mt are harvested or less than 20 percent; the United States harvests about 30 percent whereas Canada harvests less than 10 percent (Table 4).

About 60 percent of the wood that is harvested is for lumber; less than 40 percent is for pulpwood (USDA 1977, CYB 1977). This is because lumber is a more economically valuable product than is pulpwood (USDA 1977).

Use of Forest Remains

When forests are harvested for timber and pulpwood, from 7 percent to 50 percent of the wood remains in the forest areas as a slash residue. This has potential for energy conversion (Boyle et al. 1973, Franklin 1973). Also in the harvested plot areas are weed and cull trees that could be utilized for fuel. A total of about 340 Mt of forest remains are left from forestry operations in the United States (J. Zerbe, USDA-Forest Service, personal communication 1978) and about 110 Mt remains are left in Canada.

These forest remains are distributed at an estimated 16 metric tons per hectare. Air dried to 17 percent moisture, they would provide 4,600 kcal per kilogram of slash. Thus, an average of 16 metric tons of slash will yield about 74 million kcal of energy if burned at the forest site.

The wood energy that lies in the forest must be collected and transported to the consumer. This requires energy. For example, the transport of 1 metric ton of wood 100 miles (160 km) by truck requires about 133,000 kcal—hence, one of the

Table 4. Forest biomass production in the United States and Canada (USBC 1977, CYB 1977).

Country	Millions ha	Biomass (dry) metric tons/ha	Total biomass produced (dry) Mt[a]	Total biomass harvested (dry) Mt
United States				
Forest land	247	4.0	988	310
Farmland	503	3.6	1,822	1,329
Other	299	1.4	413	0
Total	1,049		3,223	1,639
Canada				
Forest land	326	4.0	1,304	100
Farmland	69	3.6	248	181
Other	603	1.4	844	0
Total	998		2,396	281

[a]Mt = million metric tons

reasons for locating an electrical plant close to the forest. Both to harvest and transport forest slash on 1 hectare to an electrical plant located within an average distance of 25 miles (40 km) of the forest required an additional energy input of about 1 million kcal.

To supply a 100 MW power plant with sufficient forest slash for one year requires an area of 22,750 hectares. If we assume a minimal forest maturity rate of 30 years, then to supply the annual needs of the power plant using forest slash, a forested area of 682,500 hectares would be necessary. This means that 13.7 hectares of forest land are needed just to supply the yearly electrical needs of each person in the town of about 50,000.

A major question remains to be answered, that is how much of the total forest slash actually could be utilized? One difficulty is the location and removal of the resources from steep slopes or other relatively inaccessible areas. In some regions the forest area and slash is located too far from communities that need the energy. Obviously the community of energy consumers must also be located in an area that is primarily forested for anything less than this will result in transporting distances that would be too energy expensive.

Environmental Implications of Slash and Whole Tree Removal

Improper logging techniques leave in their aftermath soil erosion and compaction of soil problems (Montgomery 1976). If both logs and slash were harvested, heavy machinery would be needed to collect and move the slash to a chipper. These operations might intensify the erosion problem.

Leaving slash on the land protects the soil from rainfall and rapid runoff and thereby helps control the soil erosion problem after logging (Haupt and Kidd 1965, Rothacher and Lopushinsky 1974, Pecoraro et al. 1977). The removal of slash and/or whole tree harvesting for firewood from steep slopes where the potential for soil erosion is high is particularly serious.

Soil erosion results in degrading the fertility of the land and also adds substantially to the sedimentation of streams and rivers. Overall this can have a detrimental impact upon surrounding ecosystems (Pimentel et al. 1976, Likens et al. 1978).

The removal of whole trees from a logging site, which is the result of both logging and removing slash, and/or whole tree harvesting for fuelwood, has important environmental effects on nutrient sources (Morrow 1978). Removal of whole trees results in carrying away the essential nutrients required for forest growth. For example, from 200 to 300 kg of nitrogen is removed per hectare of forest when whole trees are harvested (Table 5). The quantity of nitrogen and other nutrients (phosphorus, potassium, calcium, magnesium, etc.) that are removed depends on the tree species and size of trees (Kimmins 1977). Harvesting hardwood slash can double the amount of potassium and calcium removed and triple the amount of nitrogen removed (Likens et al. 1978).

The problems of whole tree harvesting and nutrient replacement are related to: type of tree removed; soil type; slope of the site; period between harvests; and the availability of nutrients from soil breakdown and the atmosphere. All of these aspects would have to be carefully analyzed to determine the appropriate nutrient applications.

Several recent studies have indicated that nutrients can be depleted if slash and/or whole trees are harvested (White 1974, Boyle 1975, Patric and Smith 1975, Norton and Young 1976, Kimmins and Krumlik 1976). To offset the loss of nutrients by slash and whole tree harvesting and intensified soil erosion, nutrients would have to be added as fertilizer. The added energy inputs would be determined by the quantities of fertilizers applied.

For our analysis, we calculated that an input of 4 million kcal would be required per hectare to replace the nutrients being removed by slash removal. Adding this 4 million input to the 1 million for collecting the slash, the total input for harvesting slash is 5 million kcal. Thus, the net energy yield from the 74 million kcal of slash present is 69 million kcal per hectare.

In addition to the soil erosion and water runoff problems associated with slash and whole tree removal is the environmental effect of reducing ground cover. This

Table 5. Nutrients removed by whole tree harvest.

	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Calcium (kg/ha)	Magnesium (kg/ha)
Aspen-hardwood forest (Boyle 1975)					
Nutrients removed with tree harvest	192	27	130	428	-
Nutrients available in soil (6 inches) [15.2 cm]	27	114	128	656	-
Spruce-fir forest (Kimmins and Krumlik 1976)					
Nutrients removed with tree harvest	324	42	150	537	31
Nutrients added by atmospheric inputs over 120 year period	108	5	228	780	168

ground cover is essential for many small mammals, such as rabbits and birds. If slash and whole tree removal eventually resulted in reduced forest productivity, this would also reduce the natural energy sources for many organisms. The overall result would be a deterioration of the environment for wildlife.

Whole trees can be removed from forests during thinning operations. This procedure may result in minimal effects on the environment. One difficulty in harvesting thinned trees is to remove them from the forest with little energy and labor. If the thinned trees are cut up into small units so they can be carried out, then the labor and energy inputs as well as dollar costs are high.

Thinning forests has advantages in enhancing the growth in the remaining forest trees (Oglesby and Morrow 1978). In addition, the diversity of the forest is maintained for wildlife.

Fuel-Wood Farming

Tree species can be cultured as an energy crop source and might be advantageous when the land is not being used for either agricultural or forestry production. The trees on fuel-wood farms would be planted densely, with 3 or 4 foot (1–1.3m) intervals in each row and between rows, and would be harvested by mowing every two to three years. This is similar to forage production except that forage harvest is annual. The general management of these fuel-wood farms would be similar to other crop production, requiring relatively intensive management techniques, including fertilization, weed control with herbicides, and other similar inputs.

If tree species like sycamore, poplar, or alder were grown for biomass energy conversion, they could be cut at intervals ranging from 2 to 3 years for sycamore and poplar (McAlpine et al. 1966, Dutrow 1971, Steinbeck et al. 1972, Gordon 1975) to 8–11 years for alder (DeBell 1975). These woods are dense and contain about 50 percent moisture when harvested. The yields obtained would depend on the quality of the land, the form of management, and whether fertilizers were used. Average annual production on marginal land is estimated to be 6 metric tons of the biomass per hectare (50 percent moisture) (Steinbeck et al. 1972, Gordon 1975, DeBell 1975, Johnson 1975, White and Hook 1975, Inman 1977, Howlett and Gamache 1977).

To harvest the trees, machinery would be employed to mow and chop the wood into chips for transport to a power plant for storage and conversion. Note that the inputs for harvest and transport are relatively substantial and make up almost one-half of the total energy input (Table 6).

The 6 metric tons of wood harvested per hectare would produce about 3,740 kcal of energy per kilogram of wood, or a total of 22.4×10^6 kcal per hectare harvested (this is an optimistic estimate). The total energy input, including fertilizers, was estimated to be about 1.8 million kcal (Table 6). This minus the energy inputs results in an estimated yield of 20.6 million kcal per hectare for fuel-wood farming.

As mentioned, a 100 MW plant serving a population of about 50,000 people requires 1.57×10^{12} kcal in fuel annually, plus 2.8 million kcal for annual operating costs. To meet these operating costs from fuel wood would require the annual harvesting of 76,210 hectares of sycamore. If the sycamore were harvested every second year, about twice this area, or about 152,420 hectares of fuel-wood planta-

Table 6. Average annual energy inputs needed per hectare to produce and transport sycamore fuel wood to an electric plant for energy conversion.
Note: Harvest is assumed to be 6 metric tons per hectare. Assuming this wood contains 50 percent moisture, then its energy potential is 3,740 kcal per kg. Hence, about 22.4 × 10^6 kcal is produced per hectare. Minus the production costs the net yield is 20.6 × 10^6 kcal per hectare.

Inputs	Quantity/hectare	Kcal(10^3)	Cost
Labor	10 hours[a]	——	$ 60
Machinery (10 year life)	6 kg[a]	108	9
Petroleum	56 liters[a]	639	6
Land rental	——	——	100
Phosphorus	6 kg[b]	18	1
Potassium	34 kg[b]	54	3
Nitrogen	60 kg[b]	882	9
Calcium	60 kg[b]	19	2
Electricity	12.5 kwh[a]	38	1
Transport	——	16	1
Total		1,774	$192

[a]Rich and Bauer 1975.
[b]Estimated based on the nutrients removed in the wood (Young et al. 1965, Dyer 1967, Boyle 1975).

tion would be needed. This amounts to more than 3 hectares of fuel wood to meet each person's electrical energy needs.

If about 40 million hectares of marginal land in North America could be used for fuel-wood production without infringing on agricultural and forestry production, an estimated 120 Mt of fuel wood could be produced per year. Based on the availability of 120 Mt of fuel wood and the calculated net energy yield (Table 6), a calculated 104 × 10^{12} kcal of electrical energy could be produced per year.

Sycamore and other similar fuel-wood species mentioned require about 60 cm of rainfall per year (Salo et al. 1977). Therefore a different strategy for biomass energy production would be required to use the additional 10 million hectares that have only 20 to 25 cm of rainfall.

Calvin (1977a, 1977b) suggested that "petroleum plants could be cultured in dry land areas that have minimal use except as rangeland." Several species of plants, including some of the *Euphorbia* species, produce hydrocarbon substances related to petroleum. Because of the dry conditions under which these hydrocarbon plants grow, yields in hydrocarbon energy (kcal) are estimated to be only half of that of the fuel-wood plantation. Analyzing the available land in North America, we estimate that about 20 million hectares of dry land could be managed as hydrocarbon plantations. Assuming that energy production costs and conversions are similar to fuel-wood farming, the 20 million hectares could yield 26 × 10^{12} kcal of electrical energy. Perhaps the more valuable use of hydrocarbons would be as feedstocks for the petrochemical industry.

Environmental Implications of Fuel-Wood Farms

Undertaking large-scale production of fuel wood can be expected to have an enormous impact on existing ecosystems (Morrow 1978, Decker 1979). The obvious energy advantages of fuel-wood farming necessitate consideration of tradeoffs with agriculture, forestry, and other important aspects of society in making use of fuel wood for energy production. All of these interdependent factors must be carefully examined and evaluated before any decisions are made concerning the advisability of energy production from fuel wood.

A foremost consideration is the status of available land. Land is needed for fuel-wood farming but land is becoming increasingly scarce. For example, we know agricultural and forestry acreages have been shrinking due to the spread of highways and urbanization. In the United States within the past 30 years an area of agricultural land equivalent to the state of Nebraska has been covered. The total arable land in the United States that is now covered with highways and housing is equal in area to Nebraska and Ohio combined (Pimentel et al. 1976).

Thus, prime agricultural land in North America is at a premium and must be preserved for food/fiber crops. Furthermore the more than 1 billion hectares presently in pasture and rangeland are necessary for livestock production. Some presently unused land is either too steep, too rocky, or too poorly drained to be suited for fuel-wood farming.

When all these land areas are removed there remains about 40 million hectares of land in North America with 60 or more cm of rainfall plus another 20 million hectares of land with 20 cm of rainfall that might be used for fuel-wood or hydrocarbon plantations. Use of this land probably would not adversely affect agricultural and forestry production in North America. This estimate contrasts with Inman's (1977) suggestion to convert agricultural and commercial forest land into fuel-wood farms and seems impractical because the economic value of products from both agricultural and forestry production is significantly higher than that possible in the case of producing energy from fuel-wood farming. Furthermore at a time when food supplies must increase to feed increasing populations, agricultural land use cannot be reduced. Another estimate of how much land is available for fuel-wood farms has been made by Fraser et al. (1976) who suggest 70 million hectares are usable in the United States alone. Pimentel et al. (1978), however, estimated that a more realistic figure is about 30 million hectares for the United States or about one-half that recommended by Fraser et al. In this analysis we used a figure of 60 million hectares total for the United States and Canada.

Erosion rates on fuel-wood farms hopefully would be less than those in normal forestry operations including slash removal because the tree species utilized on fuel-wood farms would be planted relatively closely to one another and would be allowed to regrow by sprouting from the stumps. This type of growth would provide some protection from water runoff and the extensive root systems would help stabilize the soil. Additional erosion control would result if the leaves were not harvested and left at the site to provide barriers to the rainfall. In addition, the organic matter from root and leaf production would contribute to soil quality and structure.

As far as erosion is concerned, probably the most serious problem would be the roads to the fuel-wood farms. The location of roads could be designed to minimize runoff.

In addition to land itself the nutrient quality of that land is important in crop culture. The use of poplar, sycamore, and alder trees for fuel-wood farming in a relatively short rotation of cropping of 2-3 years, can be expected to cause serious depletion of soil nutrients. Thus, the soil nutrients would have to be replaced through the use of fertilizers to prevent the rapid deterioration of the soil.

The addition of nutrients in the production costs of fuel-wood farming (Table 6) includes 6 kg/ha of phosphorus, 34 kg potassium, 60 kg nitrogen, and 60 kg calcium every other year when the plots are harvested. These amounts should maintain the nutrient level on the land for continued use, depending on the particular site and soil quality, but are an added cost.

Like agricultural production, fuel-wood farming would reduce the existing natural species diversity because a single species of tree would be planted (Pimentel et al. 1978). Insect and disease outbreaks might become a problem in these fuel-wood monocultures and would, under these conditions, require insecticides or fungicides. The necessity of using pesticides would increase both energy and environmental costs.

Fuel-wood farms might pose a fire hazard because the tree stand would be dense. Furthermore, the tree species would be low in moisture content at harvest, and especially so if their upper branches had been killed by defoliants before harvest. This technique has been suggested by Steinbeck et al. (1972). Dry woods such as this would be highly susceptible to fire.

It will be impossible to use the land converted into fuel-wood farms for recreation. The densely planted trees that will grow bushlike would be impossible to penetrate. After harvest and mowing the bare stumps and mowed area will be unsightly (Inman et al. 1977).

Although unsuitable for recreation, fuel-wood farms may be advantageous for large game, such as deer and elk. These young trees, with their abundant growth, would provide excellent browse, easily reached by deer, elk, and other large game and would also provide cover for these and other animals. As a result, fuel-wood farms would probably lead to an increase in some species populations by furnishing them with an appropriate habitat. However, as a whole the diversity of species in these monocultures would be reduced.

The Socioeconomic Impact of Fuel-Wood Farming

The labor input in fuel-wood farming is large. Thus about 10 hours of labor are required to manage and harvest on a biannual basis one hectare of fuel wood. This calculation includes the time and labor to transport the chips to the conversion site. Assuming that 60 million hectares need to be harvested annually, this would mean a total of 300 million man hours, or approximately the equivalent of 150,000 workers just on site, not including the management and support workers for such a program. If firewood were being harvested, the labor requirement would be even greater. To harvest a hectare of wood that produces about 18 cords of wood would require about 100 labor hours, assuming about 5.5 hours per cord.

Concerning the economics of fuel wood, paying about $30 per cord in rural areas such as Ithaca, New York works out to be about 98,000 kcal per dollar of wood. Producing chips is calculated to cost about $190 per hectare; this gives a net energy harvest of 20 million kcal. Based on these data the return per dollar is 105,000 kcal or similar to cord wood (Table 6).

For other forms of energy the per dollar cost was figured by multiplying production costs at the mine by a factor of three to include refining, transportation, and other costs. Based on this assumption, bituminous coal sells for 105,000 kcal per dollar, natural gas 197,000 kcal per dollar, and oil currently is about 60,000 kcal per dollar. From this it is clear that coal and the production of chips or cord wood are similar in cost. Natural gas is somewhat cheaper, while oil is more expensive than wood.

In comparing the price value of wood as fuel with that of wood as lumber, there is no doubt that wood as lumber is a far more valuable product than wood as fuel. For example, we calculated that per dollar invested in fuel-wood farming returns 105,000 kcal. For lumber production we assumed that 4 metric tons of logs are required to produce 1.5 metric tons of lumber. The value of 1 board foot was assumed to be $1.00. Based on this analysis 105,000 kcal of wood in the form of lumber has a value of about $3.60. Thus, wood in the form of lumber has a value 3.6 times that of wood as fuel. If fuel wood could be harvested in a shorter period than lumber, then this difference could be reduced somewhat.

Projections are that lumber will be even more valuable in the decades ahead, and will maintain the present price differential over fuel-wood farming in the future. Lumber is an excellent building material because it is easily handled in construction and is about one-sixth the cost of brick. Another valuable asset of wood is its natural insulating properties. Compared with brick, concrete, or steel, lumber is a poor conductor of heat and thus slows heat loss. As a building material, then, wood enjoys many advantages and will be increasingly valuable in the future.

Summary

Currently about 1 percent of U.S. energy supplies are being supplied from forests and in Canada the total is about 4 percent. The use of forests as a source of fuel could probably be increased 50–60 percent without adversely affecting the production of lumber and pulpwood supplies in these countries.

Increased use of forests and forest products as sources of energy has significant environmental and socioeconomic implications. The utilization of forest slash, for example, would intensify soil erosion and water run-off problems. In some areas with steep slopes or poor soils, the utilization of slash could result in serious environmental problems. Furthermore, the nutrients removed as slash would have to be replaced with increased fertilizer applications if productivity of the area were to be maintained.

In North America, about 60 million hectares of marginal land could be used for fuel-wood farming without jeopardizing either agricultural or forestry production. Although the use of appropriate technology would reduce the dangers of soil and water erosion, there would be some adverse environmental impact. Since the forest habitat is converted to a single species of tree growing densely, the diversity of animal life would be significantly reduced. This would be especially true if these forest plots were cut every two years as proposed.

At present, fuel wood in rural areas is priced similar to coal whereas in cities it is several times the price of coal. How wood will be priced relative to coal in the future is impossible to project because of the supply-demand questions related to lumber and pulpwood as well as energy supplies.

The production of fuel wood is a labor intensive industry. This has certain advantages with the current surplus labor market in both the United States and

Canada. Of course, some of the surplus labor would have to be moved close to the forest areas. Any large movement of a labor force has far-reaching social implications.

Thus it seems clear that forest productivity may be utilized to augment the diminishing energy supplies in North America. The extent of the use of forests will, however, involve policy decisions as to the type of conversion technology to be used, the location of forests and consumers, the forest management programs to be employed, the environmental costs of making intensive use of our forests, including the impact upon wildlife, the relative economic value of wood as fuel versus lumber, and the availability of manpower for forest culture. All these items are major considerations in determining the future use of North American forests as a source of energy. Clearly, the use of some forest slash and thinnings and fuel-wood farming have advantages in providing a limited amount of energy for the United States and Canada.

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Wildlife Administration in Canada

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Wildlife Management in Canada— A Perspective

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Introduction

Canada as a whole has good variety and reasonable abundance of wildlife. Much of this wealth is due to natural heritage, sparse human populations and light land use, but a large portion can be attributed to the desire of Canadians to maintain and enhance the resource. Without positive management over the years, Canada today would not only have far less wildlife, but would also find more of its original wildlife populations on extirpated or endangered lists.

The purpose of this paper is to examine the system of wildlife management in Canada, to touch on historic events, to look at the current situation and to probe the future. I will be sharing some of the information that has come to my attention over the past 21 years while working as a wildlife biologist and administrator in Manitoba. This base has been broadened by contacts with colleagues across Canada whom I take this opportunity to thank for their generous assistance.

Two main features characterize the system of wildlife management in Canada. One is the many values that Canadians attach to wildlife in categories such as commercial, recreational, cultural, survival, ecological, aesthetic, symbolic, historical, educational and scientific. The other is the crucial but ill-defined role of the Crown, that is, government. Wildlife is Crown property whether on Crown or private land, and governments, rather than private entrepreneurs, manage it according to their values and goals, existing laws, and custom and usage. It should be noted in this context that the "public trust doctrine," which underlies wildlife management in the United States (Bean 1977), gives way in Canada to the principle of Crown ownership.

The Crown's role in wildlife management has not been precisely established. It is usually perceived by governments as a flexible combination of protection, production, control and allocation for the purpose of providing social, cultural and economic benefits. Subroles include monitoring, research, public communication, education, interpretation, and support to the private sector. For all their wildlife management endeavors, most governments in Canada have yet to declare and take a clear and concise position in respect to long-term wildlife conservation. One noteworthy exception is a 1966 statement which outlines the intentions of the Federal Government to meet its wildlife responsibilities and to support wildlife management throughout Canada (Minister of Northern Affairs and National Resources 1966).

In this paper, *wildlife management* means any policy, legislation or program of government to protect, control, enhance, perpetuate, use or allocate wildlife. The many significant actions of the private sector are not discussed. Purposeful manipulation of wildlife populations and habitat is part of overall management and, for want of a better term, is referred to as *wildlife husbandry*. *Wildlife* is any animal so designated by governments and may be limited to certain species. Over the years, most governments in Canada have broadened their scope by lengthening their lists of species, and today most refer to "wildlife" instead of "game."

This paper emphasizes the legislative-administrative aspects of wildlife management rather than the husbandry, research and educational activities of governments. In the Canadian system of government, policy, legislation and administration are closely linked and conveniently discussed together.

Jurisdiction

Canada's Constitution, the British North America [BNA] Act of 1867, does not specify which government, central or provincial, has jurisdiction over wildlife. The Provinces, however, based on interpretations of several sections of the BNA Act, claim proprietary rights and these claims have never been seriously challenged by the Federal Government. On the other hand, the Federal Government over time has acquired leading and supporting roles in wildlife management: it is involved in a variety of activities under the authorities of the Migratory Birds Convention Act of 1917 and the Canada Wildlife Act of 1973; it manages wildlife in National Parks and in National Wildlife Areas; it is responsible for declaring game in danger of extinction and for management of Crown land in the Yukon and Northwest Territories; it negotiates international wildlife treaties and agreements; and it cooperates with other governments in Canada in management activities agreed to under the enabling provisions of the Canada Wildlife Act. Additionally, the Federal Government enters the wildlife management arena across Canada through numerous programs dealing with Native people, agriculture, forestry, regional and rural development, land, water and the environment. Thus, although there are no legal rulings which establish broad Federal authority over wildlife conservation, such as those which exist in the United States (Bean 1977), the Canadian Government plays a major role in wildlife management alongside and in partnership with the Provinces and Territories.

The Provinces play the key role in most areas of wildlife management because they have proprietary rights in wildlife and in vast tracts of land, and because wildlife is deemed to be largely a matter of local interest. What a Provincial Government does with wildlife at any particular time is part of its legislative-administrative process but is must take into consideration any applicable legislation, policies and programs of other governments. Furthermore, all governments must take into account the rights of private landowners, the special rights and claims to wildlife of Native people, the movement of wildlife across international, Provincial and Territorial borders, and the wildlife management activities of the private sector.

Jurisdiction over wildlife in Canada is complex and far from fixed. This fact seldom interferes with effective wildlife management but it requires that much time be spent in negotiation, integration and coordination. Reduction of jurisdictional uncertainties, leading to increased economy, efficiency and effectiveness in the achievement of goals, is the aspiration of many Canadians.

Legislation and Administration

Background

All executive government action in Canada, except that based on Crown prerogatives, is on the advice and with the consent of the electorate as expressed through their legislatures (Federal Parliament, Provincial Legislatures and Territorial Legislative Councils). Legislatures delegate certain authorities to the executive or administrative sectors of governments. Control over administration by a legislature is effected through (1) legislation, which may specifically demand, permit or prohibit particular action by the executive or administrative sector of government, (2) review of proposed expenditures, mostly on an annual basis, and (3) the power of censure. Major policies and procedures which a legislature wants implemented by the executive are set down in legislation; others may be assumed by implication. (Government of Manitoba 1970)

Executive sectors of government, as a rule, have not been charged by legislation with carrying out affirmative wildlife management. Hogg (1977) points out that unless there are legislative restrictions, Crown resources may be managed at the pleasure of administrations and without the necessity for legislation. Basic wildlife legislation in Canada today prohibits certain actions of the public in respect to the taking of wildlife and the use of some critical habitats. This legislation may also permit certain actions by the executive, such as control of predators and designation of wildlife lands, but it does not specifically demand or prohibit, or even mention in most cases, particular actions directed toward perpetuating or enhancing wildlife or habitat. Government administrations, however, in their roles of responsible property owners and protectors of wildlife, and using either (a) prerogative powers, (b) discretionary powers implied in protective legislation or (c) specified powers in permissive legislation, have added substantially to wildlife management initiatives down through the years.

Comparison with the United States

With the exception of a few recent innovations to be mentioned later, neither Canada as a Nation nor the individual Provinces and Territories have long-range programs for wildlife conservation with permanent funding to allow the pursuit of goals through changing governments and priorities. In contrast, much of the wildlife effort in the United States is based on time-honored conservation legislation which contains long-range objectives and provides for built-in funding through various ear-marked revenues. A huge biological-recreational system supported by government, the private sector and universities has evolved in the United States over the past 80 years, all seemingly resting on what the Director of the U. S. Fish and Wildlife Service calls "the National effort to maintain healthy, varied, and sustained populations of fish and wildlife" (National Wildlife Refuge Study Task Force 1978). This effort, however, is not without its obstacles, a major one being the lack of a clear, national, legislative policy for wildlife. Without such a policy, government tends to deal with symptoms of problems rather than causes and has developed over the years a wide array of disconnected and sometimes conflicting objectives (Warren 1978).

Canada, for several reasons, has not launched a national crusade for wildlife conservation such as exists in the United States. First, wildlife populations in Canada as a whole have not dropped to a level where governments have felt need for such a singular mission. Second, as pointed out earlier, wildlife is more a matter of local than national concern. Third, the parliamentary system, party government, collective responsibility of cabinet and a reluctance to ear-mark revenues do not naturally lead to the establishment of long-range wildlife missions as part of Provincial government administrations.

Further explanation of the third point above may be useful. At the State level in the United States, according to the Wildlife Management Institute (1977), many wildlife management responsibilities in policy, budgetary and regulatory matters are assigned, along with specific revenues, to appointed administrators. These persons often are staunch wildlife advocates. In Canada, wildlife management is the responsibility of elected officials who, in view of their total mandate, are inclined to be comprehensive in outlook and oriented more to people than to wildlife. It is of interest to note Poole's (1973) observations that recent organizational changes in the United States at the State level have had the effect of passing control over wildlife management from commissions and boards to the political structure.

Canada's system of government allows a legislature, if it is so inclined, to establish wildlife conservation as a stated objective to be pursued by either a line department or an appointed body. Delegation of authority to an appointed body is accepted procedure in a number of areas of government concern. Canadian recreational hunting groups, with a knowledge of the situation in the United States, occasionally propose delegating authority and responsibility for game husbandry to a commission along with hunting license and other revenues. Furthermore, some Native people living in remote areas would like to be placed in charge of nearby game and other wildlife populations which are integral to their way of life. No widespread support for these kinds of delegation has developed, however, beyond the creation by some governments of wildlife advisory bodies with public members and an occasional delegation of some management authority (for example, registered traplines) to specific users. Canadian legislatures, with few exceptions, still seem to prefer having wildlife administered by executive sectors of government as a responsibility of line departments with little or no outside delegation of authority, or legislative direction, requirement or restriction.

Government organization for wildlife administration at the Provincial–Territorial level follows no set pattern. Each administration organizes its affairs according to its objectives and perceptions, and any applicable legislation. New arrangements and approaches, built around concepts of major outputs (such as economic, recreational, environmental), integrated resource management and decentralization, have been common in recent years. This frequent change and experimentation is disconcerting, especially to people outside government who remember days of dealing quickly and effectively with "a person in charge of the game department." Organizational change is also common in the United States but there a greater degree of stability appears to result from the dedication of resources to wildlife conservation and the enshrinement of executive organization in legislation.

For all their differences, the two systems have produced remarkably similar results in their efforts to serve the needs of people. Each country has extensive, modern and well-funded wildlife management activities which reflect the high value placed on wildlife. The United States is faced with the problem of diversifying its activities, which presently feature sport hunting, while Canada is faced with the question of whether or not to give its diverse activities clearer identity. The United States has proclaimed wildlife conservation to be an important national objective, and has put long-range programs into place. This has not occurred as yet to the same degree in Canada. It deserves emphasis that neither country thus far has a legislatively-mandated, comprehensive national wildlife policy or a coherent national wildlife strategy.

Wildlife Programs

Early Developments

Protection of game, fur-bearing animals and other beneficial wildlife from unwise use, and predator control were the major wildlife management activities of governments from Canada's legal creation in 1867 to the early 1900s. Controls on export and sale of some species were brought in before the turn of this century in order to reduce excessive demand and illegal harvest. First area closures, given such names as refuges and parks, were established in the late 1880s and became increasingly popular in some jurisdictions after 1910. Big game was being transplanted in the early 1900s. In the 1920s, governments began devoting more time to programs dealing with fur-bearing animals and trapping. During the same period, some governments adopted strategies to provide hunting through the creation of public shooting grounds and to enhance wildlife through the introduction of exotics and by working with private landowners. In the late 1920s and 1930s, governments became aware of the need for research and for public information and education in effective administration.

Wildlife management initiatives that came to the forefront in the 1930s and 1940s included fur rehabilitation, registered traplines, and wetland and upland habitat protection and manipulation. Special consideration for Native people was also an important issue.

By the 1950s it had become apparent to most governments that their efforts to manipulate wildlife populations and habitats should be more intensive and scientific. Government game wardens and conservation officers, whose main role at the time was enforcement of acts and regulations, were not trained to assume these added responsibilities. In response to this new need, numbers of wildlife biologists and technicians increased rapidly in the 1950s and 1960s. With them came scientific inventory and monitoring of wildlife populations and habitats, land-capability studies, and biological and ecological research. New husbandry initiatives included harvest quotas and other refined hunting regulations, wildlife management areas, wildlife damage prevention and compensation, wetland and upland habitat manipulation, and the lease and purchase of private land for wildlife.

Initially, there was a tendency for government biologists to take on the role of wildlife guardians and hunting advocates with almost religious fervor. Because government policy in these areas was fuzzy, biologists moved into the vacuum under the guise of experts, and soon had sportsmen's support along with government forbearance. Some criticism of biologists gradually developed for their habit of expressing and promoting value judgments, without government sanction, on such issues as environmental impact, land use, wildlife allocation and hunting. The situation has now evolved to where biologists in government employ are more concerned with developing policy options than with pursuing quasi-professional ends.

A broad-based, national association of wildlife biologists or of wildlifers has not yet formed in Canada although there have been expressions of interest for at least the last 20 years. Inhibiting the emergence of such an organization is the difficulty of defining the role of the wildlifer to the satisfaction of professionals with various wildlife specialties. In the absence of strong Provincial and National wildlife policies and of a firm, Canada-wide wildlife conservation commitment, common ground for organization has been elusive. The tendency prevails for the several interests—administration, enforcement, education, research, husbandry, environmental protection—to group separately if at all. Some sort of organization may arise in the future out of the ongoing desire of wildlife professionals and governments to maintain consistently high levels of service.

Recent Developments

Almost overwhelming complexity entered the wildlife management scene in the 1960s. The relatively simple approach of management through regulation of harvest, plus a few stopgap measures, was proving to be less and less adequate. Requests were being made for multiple-use of Crown land, environmental protection, ecological wisdom, nonconsumptive use, goal definition, decentralization, comprehensive planning, public participation in decision making and recognition of Native and landowner rights. In keeping with the times, a national conference on "Resources for Tomorrow" was held in 1961 to examine thoroughly the role of renewable resources in Canada's development. One of the main results of the conference was the formation of today's Canadian Council of Resource and Environment Ministers, a vehicle for providing a regular exchange of views on resource policy matters among the 11 senior governments in Canada.

Shortly after the "Resources for Tomorrow" Conference, the ecological–environmental movement began in earnest. This is reflected in the 1971 *Background Study for the Science Council of Canada,* titled, "Scientific Activities in Fisheries and Wildlife Resources." Written by expert but admittedly not unbiased observers, the authors state, "We feel very strongly that the perpetuation of fish and wildlife is important to man and to the world; we make an unabashed attempt to make this the outstanding aspect of our report because we consider that the maintenance of high-quality environments throughout the world is vital to man's continuing survival'' (Pimlott et al. 1971). This theme is picked up by the Science Council in its 1973 report, titled, ''Natural Resource Policy Issues in Canada'' wherein it recommends ''that Canadians . . .begin the transition from a consumer society preoccupied with resource exploitation to a conserver society engaged in more constructive endeavors'' (Science Council of Canada 1973).

Ministers of the Crown tend to be more pragmatic in reaching decisions than the Science Council. While many government officials agreed in principle with the Council's philosophy, they could not escape the recurring question, ''What is wildlife really worth?'' Government employees have spent considerable time over the past 20 years seeking answers to that question. Numerous economic, ecological and socio-cultural evaluations have been made in order to establish bases for wildlife management decisions and expenditures under various circumstances. The outcome has been that wildlife programs have become identified more and more with particular values such as sport hunting, viewing, trapping, sustenance, tourism, education, science, and environmental quality. Governments have responded to client groups and to regions and sites where needs, wants and aspirations could be rationalized. Formal planning—socio-economic, recreational, land use, environmental, regional, watershed, urban area, agricultural, renewable resource—became a new discipline and wildlife was usually included. Never before had wildlife received the pervasive attention from government that emerged in the 1960s and 1970s.

Hunting and trapping have surfaced as important public issues during the last 15 years. Governments have been asked to consider whether the net value to society of no hunting and trapping does not actually equal or exceed the net value of these activities. Although this is an extreme view, much debate has taken place and the eventual outcome may be to persuade some governments to modify their hunting and trapping policies.

Response of governments to client groups brought the cost of government programs into sharper focus and led to the suggestion that ''Programs to provide harvestable surpluses of wildlife should be financed through tax upon special users, and upon persons benefiting directly therefrom. All such tax revenues should be dedicated to fish and wildlife purposes'' (Mair 1961). Today there are in place in several Provinces, in addition to regular license fees which enter general revenue, special charges on recreational hunters that support wildlife damage control and habitat development programs. There also are trust funds established through various government and private sources for the preservation and development of specific upland and wetland sites.

In attempts to assist in socio-economic development, governments have examined the feasibility of many wildlife-related schemes. Reindeer, big game and beaver ranching, moose domestication, wildlife-based tourism, community wildlife management areas, wild fur promotion, and sale of blackbirds and wildlife by-products, are some of the ideas that have received attention in recent years.

It should also be noted that some resource management analysts are actively questioning the rationale for the universal ban on the sale of most game. They suggest that the blanket ban prevents realization of benefits which would accrue from some forms of commercialization (Lemieux 1978). Desmeules (1978) expands the thesis that the range of wildlife uses should be extended as much as possible in order to arouse maximum sympathy for and interest in wildlife.

Future Outlook

Notwithstanding the widespread attention that governments and the private sector are directing toward wildlife management, the soundness of the total effort is still an open question. Much of what is being done to protect, enhance, perpetuate and control wildlife has appearances of being disconnected, uncoordinated and not related to an all-embracing strategy. To a large extent, wildlife is being managed on the basis of the assorted value judgments of several changing governments without consistent philosophy, an overall plan or clear-cut principles. This gives rise to serious concerns that today's wildlife programs may be suffering from the effects of lack of continuity and stability, while tomorrow's wildlife resources may turn out to be far poorer than what is presently hoped for and within the power of governments and the private sector to perpetuate.

In this vein, the Science Council of Canada (1970) recommended a new national goal for Canada, "a stable and healthy environment of high ecological quality, maintained over the long term." Clarke (1974) may have been getting to the root of the issue when he wrote, "The purpose of wildlife policy is the preservation of the soul of Canada." These points were examined further by several speakers at the 1975 Federal-Provincial Wildlife Conference. Poole (1975), for example, suggested that an ideal goal might be to strive for the widest diversity, distribution and abundance of wildlife. All government and private initiatives would then be judged against this goal and, as far as possible, brought into line with it. Although this may be happening now in some parts of Canada and may be an emerging trend, a guiding document would seem to be required in order to make the approach more effective.

Many wildlife conservationists see the need for comprehensive and forward-looking wildlife strategies underlying the numerous government initiatives in wildlife management. Considering the present cost, size and complexity of wildlife management in Canada, which involves two orders of government, the private sector, many organizational units and numerous interactions, it seems inevitable that such strategies will soon be demanded by governments. The Canadian Council of Resource and Environment Ministers is currently working toward a forestry strategy, and it may be only a matter of time before government-commissioned studies are launched on Canada's wildlife future—studies which will produce firm and reliable guidelines for management of wildlife in Canada in the 1980s and beyond.

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Federal Roles in Wildlife Management in Canada

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When I suggested to the chairman that it would be better to change the title of this talk from "The federal mandate in wildlife management" to something rather broader and less pompous, I thought I knew what parts the federal government was supposed to play in the complicated game of wildlife management. When I looked more closely I found more complexity than expected. The manuals on successful public speaking insist however on the necessity for making things sound simple. So I will skim superficially through the range of responsibilities and linger longer only amongst the simple-minded concerns of the Canadian Wildlife Service (CWS), a modest organization recently descirbed by an academic observer as "lacks clout in government circles and the ability to muster financial and other support." (Hunt et al. 1979).

It would be an exaggeration to say that the Royal Canadian Mounted Police play the largest federal role in wildlife management in Canada. Yet, as most hunters of migratory game birds are malefactors, in spirit if not, from want of opportunity, in practice, nagging uncertainty about the appearance of a policeman round the next bend is probably the dominating federal presence in Canadian waterfowl management. People are far more conscious of the prohibitive nature of regulations than of the far more potent activities of those federal agencies that influence wildlife habitat. Parks Canada, the national parks service, is an immediate exception to that generalization, but not really a major one. Federal land holdings directly related to wildlife, whether National Parks or National Wildlife Areas administered by CWS, include some important sites. But they are, and always will be, so small a proportion of the total area of Canada or even of areas of high value to wildlife that their effects on the continued well-being of wildlife are relatively minor. In comparison, several federal agencies that have no direct interest in, nor responsibility for, wildlife have had profound effects on the distribution of mammals and birds. The Departments of Agriculture, of Energy, Mines and Resources, of Finance, of Indian and Northern Affairs, of Industry, Trade and Commerce and of Regional Economic Expansion as well as the Privy Council Office and Treasury Board, by virtue of their control of federal funds and permits in influencing agricultural and industrial uses of land are all, I suggest, more powerful than the Department of Environment. I roll off that list of names not with the object of shuffling off responsibility but to draw attention to the fact that in order to help wildlife it may well be much more important to influence the practices of non-responsible agencies than to act directly. That is of course, as true for provincial agencies as for federal ones. One of the weaknesses of wildlife agencies in this respect has been the preponderance of ex-biologists amongst their senior staff. They need more professional fixers.

Having, by way of introduction, gone out of my way to deflate the importance of the federal Department of the Environment and of the Canadian Wildlife Service by setting them in the context of more powerful departments, let me turn to my central task of re-inflation.

The Canadian Wildlife Service performs several positive functions, stemming from two pieces of federal legislation, the Migratory Birds Convention Act, of 1917 and the Canada Wildlife Act, of 1973. You have already heard from Mr. Bossenmaier some of the historical background for these Acts and other legislation relating to wildlife.

I can therefore concentrate on where we are now and where we may be going. The subject would be even less interesting than it now is were there not several different opinions on the distribution of legislative powers between the Federal and Provincial governments. My legal advice comes from the Federal Department of Justice: biologists-turned-administrators are wasting everyone's time if they put forward legal interpretations of their own.

The state of the law at any time imposes limits on what governments and citizens can do in the interests of wildlife. Often those limits seem unfortunate. Yet governments must abide by the law, even while seeking to change it where necessary. What should be intolerable is that the state of the law is sometimes used to justify inaction or timid indecision so that opportunities are lost. I will deal as briefly as I can with those questions of legislative powers relating to wildlife which impede actions by the Federal and Provincial governments, singly or in collaboration.

The issue that seems to generate most Federal-Provincial heat is who has the power to make laws concerning the ownership, hunting, management and conservation of wildlife, rather than what such laws should permit or prohibit. The British North America Act of 1867 (BNA), which serves at present as Canada's Constitution, describes in Section 91 those legislative powers exclusive to Parliament (that is, Federal) and in Section 92 those powers assigned to the Provinces. Unfortunately wildlife, other than "Sea Coast and Inland Fisheries" (with which I am not concerned in this paper) is not mentioned in either section of the BNA Act.

Subsections (13) and (16) of Section 92 deal with the exclusive powers of Provincial legislatures to make laws in relation to matters coming within "Property and Civil Rights in the Province" and "Generally all Matters of a merely local or private nature in the Province." Jurisprudence has determined that game laws, generally speaking, fall under these two subsections. The common law proprietary rights of the Provinces over wildlife inhabiting Crown lands, as well as Provincial statutory ownership of all wildlife in some provinces, confer wide legislative powers.

However the Federal Government has legislative powers in the wildlife field too, most clearly in respect of migratory birds. Secton 132 of the BNA Act states that "The Parliament and Government of Canada shall have all Powers necessary or proper for performing the obligations of Canada or of any Province thereof, as Part of the British Empire, towards Foreign Countries, arising under Treaties between the Empire and such Foreign Countries." The Migratory Birds Convention signed in 1916 by the United States and by Great Britain on behalf of Canada is such a treaty. The Parliament of Canada has full jurisdiction to enact all measures necessary to effectively enforce the Convention.

Some Provinces have argued that the Migratory Birds Convention only authorizes the Federal Government to "adopt some uniform system of protection which shall effectively accomplish" the objects of "saving from indiscriminate slaughter and of insuring the preservation of such migratory birds are either useful to man or are harmless,'' in the language of the preamble to the Convention itself. They contend that Provincial game laws can include provisions with respect to migratory birds that are not coincident with those of the Migratory Birds Convention Act and Regulations. The Federal position is that no Province, Territory or municipality may make regulations relating to the taking of migratory birds which are at variance with those Federal regulations currently in force, although it is, of course, possible for them to make regulations for the purpose of controlling activities incidental to the hunting of migratory birds, such as the carriage and discharge of firearms. Case law indicates that Provincial legislation giving further protection to game than is contained in Federal regulations will not be regarded as being in conflict with the Federal legislation. If there is a real conflict between the Federal legislation and any valid Provincial game law, the Federal legislation will certainly prevail.

It is undoubtedly an odd state of affairs that the responsiblitity for migratory birds should be separated from that for other forms of wildlife. In recent negotiations between the Federal and Provincial governments and representatives of several groups of indigenous peoples the artificiality of that separation has been very apparent. If in the course of a year people following a subsistence way of life in the Northwest Territories turn successively from migratory birds to caribou to fish as sources of animal protein, their activities fall in turn under the aegis of the Federal Department of the Environment, the Government of the Northwest Territories and the Federal Department of Fisheries and Ocean Affairs. Clearly the task of those departments is to integrate and harmonize their activities, to ensure that the needs of the people are met without over-harvesting any of the species being used.

The CWS has a particularly complicated task in that respect, because the geese being taken by the Inuit of Banks Island or the Cree of James Bay are also used by many other Canadians and Americans, all the way to the Gulf coast. The recent signature of a protocol to the Migratory Birds Convention which will make it possible for the U.S. to legalize subsistence hunting in Alaska and for Canada to do so for Indians and Inuit is a necessary step towards reconciling the needs of northern hunters with those of hunters further south. Though many people are anxious lest such special provisions should lead to increased kill of migratory game birds, that is not the intention of either federal government. I believe that, on the contrary, it will improve the chances of keeping the kill to safe levels, because it will enable us to work openly with the subsistence hunters instead of pretending that they don't exist.

In the Provinces, too, the need is for increasing involvement of migratory game bird hunters in the management of their own activities, because ''self-policing'' and ''peer pressure'' are essential ingredients of hunter management, unless we are prepared to impose and enforce extremely severe restraints on hunters, which clearly we are not.

In the autumn of 1978 over 525,000 people bought Migratory Game Bird Hunting Permits in Canada, a record number, despite unpromising conditions in the prairie provinces. So the demand for migratory game bird hunting in Canada is not decreasing, in terms of the numbers of people who are prepared to take part, even if in some parts of the country the opportunities to do so are being diminished, by growing difficulties of access, by compeition or by reduced stocks of birds.

The provision of opportunities to hunt migratory game birds is one of the contentious areas of Federal–Provincial relations concerning wildlife. Over the years there has grown up a tacit understanding that while the CWS gives its first attention to preserving the stocks of birds, the Provinces give priority to maintaining hunting opportunities for their hunters. Neither level of government has any binding legal obligation to maintain migratory game bird populations at harvestable levels, although in northern Quebec under the terms of the James Bay and Northern Quebec Agreement of 1975 (Section 24.6.5) hunters in the Territory are guaranteed "at least the same percentage of the total kill from each population as is presently hunted and harvested." There is some uncertainty here, depending on the definition of "the total kill figures for each migratory bird population." Does that mean the total kill in Canada or the kill in all those areas frequented by the bird populations originating in or passing through northern Quebec, which might also include Mexico as well as the USA? If the kill outside Canada is to be included in the calculations—as was I believe the intention of the persons drafting that section of the Agreement—it looks as if Canada might be obliged at some time to seek formal agreements about harvest quotas with the U.S., at least with respect to those migratory game bird stocks from Quebec.

The Agreement in Principle reached last year with COPE, on behalf of the Inuvialuit who live in a large area of the Western Arctic, also requires the establishment of harvestable quotas for migratory game birds, as well as other game animals. Similar provisions seem likely to appear in other Federal agreements with northern peoples in the course of land claim negotiations. I don't wish to spend long on a subject that will be discussed more fully in a later session of this conference. My object here is to point out that in this field the pace is now being set by Native hunting requirements, a total reversal of the situation that obtained before the James Bay negotiations began in 1974. The idea that the kill by subsistence hunters is of little importance is dead—even though it is probably true that in most of Canada the use of migratory birds by indigenous people is small.

Returning to hunting of migratory game birds by non-Native people, I believe it to be a hazardous over-simplification to see the task of a Provincial wildlife department as being to maximize or optimize the hunting opportunities of people in that Province while leaving the responsibility for national and international management of the stocks of birds with the Federal Government. Admittedly, it appears from outside that in the USA the relationship between the States and the Federal government is of that character, helped by the "Federal framework" approach, in which States select seasons within outer limits set by the U.S. Fish and Wildlife Service. Some Provincial wildlife agencies have suggested that a similar system be used in Canada. In Canada there is little room for manoeuvre by Provinces within broad limits set Federally, because emigration of the birds in the autumn puts an effective end to the hunting seasons, usually well short of the maximum season length (109 days) permitted in both countries by the Migratory Birds Convention.

I have earlier indicated that there are legal objections to a Province seeking to set regulations dealing with migratory birds because the existence of the Federal authority leaves a Provincial legislature no authority to exercise with that end in view. I see this not just as a tiresome technicality but as fortuitous legal support for a management principle of importance in the exploitation of a migratory resource: have as few hands on the wheel as are necessary for control and don't let the back-seat drivers touch it.

In practice we are now working with the Provinces in devising simplified migratory bird hunting regulations intended to be changed infrequently and only in response to clear biological evidence of mischief caused by over-harvesting. We are deliberately abandoning the concept of fine tuning the hunting kill by means of regulations because of the mounting evidence that the responses of hunters to frequent and intricate changes are so incomplete—whether from ignorance or lack of acceptance—that subtle changes are unlikely to produce their intended effects. So far as we can make out, regulations requiring hunters to recognize their quarry, beyond perhaps distinguishing white geese from dark ones, or geese from ducks, are useless. We see no future in using a points system to replace a simple bag limit. Alteration of opening dates is an effective device, though varying widely in effectiveness in different parts of the country and between groups of quarry species. The use of split seasons, so as to allow winter hunting in those areas, such as Nova Scotia and British Columbia, where it is both profitable to hunters and safe for the stocks of their quarry, does seem to spread hunting effort in the desired way. The most effective way to protect stocks of most species that are in need of special care seems to be by area closures, either by a temporary total ban or by using delayed openings or shortened seasons in clearly defined areas. We envisage a working rule that no changes in regulations will be made without suitable monitoring of their effects. It is pointless to make an imperceptible change, as has happened in the past, unless one takes the cynical attitude of giving the customer what he seems to want "because it won't make any difference to the birds anyway."

We see the setting of Federal regulations governing the hunting of migratory game birds as involving the collaboration and, wherever possible, the concurrence of the Provincial wildlife agencies because they can help us to ensure that the full range of peoples' interests are known to the decision makers. But we also see, more clearly than before, a need to consult more widely, with national and regional wildlife interest groups, such as the Canadian Wildlife Federation and Canadian Nature Federation, as well as with representatives of Native hunting groups and of people opposed to hunting. Except as a consequence of the James Bay Agreement, these wider consultations have as yet no formal basis. Canada does not have the elaborate procedures for providing public input that are now built into the setting of U.S. regulations. Perhaps we, as Federal bureaucrats, are lucky in that respect. But we would be foolish to ignore what the American process can tell us about the interests and arguments that should be taken into consideration.

One way in which both the U.S. and Canada have been trying to move towards a rational use of North American migratory game bird resource is by developing population goals and objectives, at least for some of the principal quarry species. CWS is under pressure to do so from regulatory agencies within the Federal Government, such as Treasury Board and the Privy Council Office, as well as from some Provincial agencies and some of our own staff. We have made considerable progress in identifying and justifying such objectives as we try to complete a national waterfowl management plan. But I see no reason to think that ecological planning is likely to be any more useful or reliable than economic planning and am sure that none of us should take our efforts in this respect too seriously. The best we can hope to do is a bit of speeding up or slowing down—whether we are using hunting regulations as our instrument or any other device for helping wildlife populations.

I referred earlier to the Canada Wildlife Act of 1973 as the second piece of Federal legislation on which CWS activities are based. This was passed primarily to help deal with wildlife habitat preservation, on which the Migratory Birds Convention had unfortunately been almost silent. While it is much too soon to despair of the Canada Wildlife Act, it has so far been of limited service. One of its major deficiencies is that it does not oblige the Federal Government to provide funds for the activities it makes possible, such as the acquisition and management of lands for wildlife purposes. CWS has had since 1966 a habitat and acquistion program, to which the Canada Wildlife Act belatedly gave some legitimacy. But it has been meagrely funded. In particular, funds for the proper management of the system of National Wildlife Areas were not identified in the Act as an essential requirement, which they undoubtedly are. The lack of public support for this program was demonstrated in September last year when a major reduction of the annual acquisition budget, from $1.1 million to $400,000, was announced in a list of government economy measures.

In principle a reduction in a Federal wildlife habitat program ought not to matter. Indeed such a Federal program ought not to be necessary, because the responsibility for land management in Canada is clearly Provincial. Yet the sad fact is that no Province has an adequate wildlife habitat preservation program and most have no such program at all. It had been hoped that the Canada Wildlife Act would help by permitting and encouraging joint Federal–Provincial action. But this has so far been limited and ineffectual because of lack of funding and of Provincial unwillingness to allow a Federal intrusion into a Provincial concern. Of course, control of land use is everywhere a warm political subject. What is now clear is that, in Canada, proper wildlife habitat protection will continue to be a victim of the battles, at least until the extent and intensity of public interest is demonstrated far more clearly than it has been hitherto. We bureaucrats are to blame, because we have not identified what needs to be done and why, but the interested public are to blame too. There are several private organizations active in the field, some with success at the local level, but the national organizations have done far less well than their counterparts in the USA or in several western European countries.

I hope that CWS can improve its performance, despite budget cuts, in the next few years, but I find myself in complete agreement with Professor Constance Hunt's description of the Canada Wildlife Act and the CWS in a recent publication (Hunt et al. 1979): "The Canada Wildlife Act also exhibits deficiencies when viewed in the context of wilderness protection in the northern Yukon. The boundaries of national wildlife areas are not legislatively set, and therefore can be altered with relative ease. . . . The act itself does not restrict environmentally-damaging activities in national wildlife areas. To a limited degree this is accomplished by legislation, but the legislative protection is weak. CWS is not seen as a strong agency within government; it is therefore questionable how effective an advocate it would be when points of contention arose. Finally the wildlife act is relatively young, with the result that many key issues are unresolved. Moreover, there is a lack of experience and history to rely upon in dealing with difficult problems in wildlife areas."

If the Provinces have their way, CWS, as part of the Federal Government, will continue to be "not seen as a strong agency." I would like to think that, in the crucial matter of wildlife habitat protection, Federal weakness can be more than offset by Provincial strength. But where is that strength to come from? And can it come soon enough? Would anyone care to bet?

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Citizen View of Wildlife Enforcement

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Perhaps one of the more controversial and talked about areas of wildlife management is that of law enforcement. The first form of wildlife protection, its history goes back thousands of years. The first formal legislative program on the North American Continent was in 1718 when the State of Massachusetts declared a closed season on deer. In 1850, the same state organized the first game warden system. Wildlife protection through legislation and enforcement was the general trend until the 1930s when Aldo Leopold introduced to the North American scene the concept of the scientific management of fish and wildlife resources. The new approach took hold quickly and today it is virtually "the way of life" for resource management agencies.

While the scientific approach grew in practice, reliance on law enforcement diminished, with the decline most prominent in the past two decades. Generally, those charged with responsibility for resource management believed a more knowledgeable and well informed public, with an understanding of the scientific principles of management, would resolve most of the types of problems that in the past were responded to by way of legislation and enforcement. Many veteran resource enforcement administrators who worked during the transition have made the observation that the enforcement function was retained basically because of the public, and was generally looked upon by the organization as a necessary evil rather than a legitimate partner in the management process. In fact, some suggest the public was effectively misled in relation to some matters relative to resource enforcement.

Though the theory of acquiring cooperation through understanding seems reasonable, it has not been the panacea some expected it to be. There is some evidence to suggest administrators may have under-estimated or neglected to determine the implications of de-emphasis of the enforcement function as it relates to general public perceptions and expectations for service. In the past few years, there have been indications of public unrest with enforcement-related matters. These are taking the form of such things as resolutions and legislative bills to transfer resource enforcement to state police function, earmarking of special funds for part-time enforcement assistance; public inquiries resulting in part from complaints relating to administration of regulations. Other occurrences such as the establishment of the regulatory agencies to supervise environmental laws and creation of new departments at state and provincial levels may be reflection of concern over past performance.

Many enforcement administrators have recognized growing public concerns about resource enforcement and the need to acquire a better understanding of user needs and expectations. Some effort, when financial capability has existed, has been directed to research in an attempt to determine such things as public perceptions of enforcement personnel, overall effectiveness of enforcement in achieving organization goals and in providing services to the public who pay the cost of wildlife management.

We have in the past 30 years learned much about the biology of wildlife and fish but have done pitifully little to evaluate and find solutions to the difficult problem relative to understanding people—their perceptions and needs as they relate to the fish and wildlife resource picture. I find it distressing that, of nine research topics in Special Session 2 of this Conference, none appears to deal with people or the law enforcement function in wildlife administration, either in Canada or in the U.S.

Something that is obvious to people involved in the profession of enforcing wildlife and fishery legislation is the difference in values placed on enforcement by the public as opposed to the majority of senior resource directors, ministers etc. There has been some research conducted which lends support to that observation. T. C. Bjornn (1976) who researched the opinions of the preferences of Idaho hunters and the Idaho Fish and Game Department employees found that hunters rated law enforcement, habitat and winter feeding as most important, while the department employees ranked habitat improvement and acquisition of wilderness the highest. In further research, Bjornn and Dalke found that the public perceive the most important activities of the department as law enforcement, habitat improvement and winter feeding. Other work by Bjornn and Williams found, in a survey covering approximately 10,000 persons, that hunters reported being satisfied with management policies and hunting experience but stated that stronger emphasis on law enforcement by the fish and game department was required.

The research mentioned above reflects public recognition and desire for law enforcement services and this determination should not be surprising. It is understandable why department perceptions and judgment may be different. For example, seldom does the landowner complain about destruction of habitat by burning a slough bottom but that same person will register a complaint about a trespass or the taking of a hen pheasant on that burned area.

Departments must be concerned with the resource in a macro-management perspective while the public is exposed to day-by-day single incidents. Incidents which, to them, are anti-social and, generally, illegal. It is apparent that politicians, ministers, deputies, directors—whatever their title, often do not place the same value on managing the behavior of the resource users to the same degree the public does. One or two ducks over the limit does not generate concerns from senior resource managers or politicians but, to the unsuccessful hunter with his 14-year old son out for the first time, it is a major issue, one for which he expects positive action, not passive acceptance. The same principle applies to fish—one or two over the limit is not important except perhaps to those who do not catch a fish. Remember, that is the majority of fisherman—it's been said that 90 percent of the fish are caught by 10 percent of the anglers. The odds are that those two extra fish will generate more dissatisfaction than support. In the actual field situation, the majority of officers report frustration with the virtual total lack of support of understanding when they are required to enforce limit regulations. They often experience more criticism and admonishment rather then recognition of the problems which all enforcement officers face and support for the job they are doing.

It is apparent why the public's perception of performance by an agency can be much different than that of the agency and also why differences often exist within the agency itself. The public's expections are often different from those of resource departments. Knowing this fact, agencies should be meaningfully responsive to the service demand, as expressed by the public they serve.

What is enforced is not the only problem area. How the "act" of enforcing laws is done is the subject of much debate. There are hundreds of experts on how it should be done. We have our own share of armchair quarterbacks. Again, there is evidence to suggest organization and political perception of the application of laws may be infinitely different from that of the individual. Complaints commonly are received by enforcement heads within the organization or political respresentatives relating to allegations of poor officer and/or enforcement image. A claim common to all types of law enforcement agencies, it is difficult to handle effectively. What appears to be happening is the reverse situation to the senior managers macro-management approach to offence situations mentioned earlier. Politicians, directors etc. exposed to the incident, respond to the micro-situation often not taking sufficient time to reflect upon the attitudes and reactions of the majority of people.

In an attempt to better understand the public perception of officers, as well as public reaction to officer performance and acceptance or otherwise of law enforcement, a number of studies have been undertaken. One such study recently has been conducted by the University of Alberta for the Alberta Fish and Wildlife Division (Melnyk 1977). Specifically, the research was intended to determine the public attitude towards Alberta's Fish and Wildlife Officers and the laws they enforce. In part, the research was undertaken because of a perceived "image problem" within government.

The project involved the sampling by questionnaire of 136 persons convicted of Wildlife Act infractions and a general sample of 1,046 hunters taken from license holders during the same year. The study found that convicted violators and hunters from the general sample both had favorable attitudes towards officers. Predictably, violators were less favorable in their attitudes, but were still well within the favorable range. The findings of the research were not surprising to enforcement administrators generally. Most believe the same kind of research would result in similar conclusions in their jurisdictions.

It is interesting to note the conclusions made in the research were similar to two independent perception studies conducted for major police forces serving in Alberta. Both judged the public perception of the police to be positive.

One area that may reflect upon the public's attitude toward resource law enforcement is their concern about the increase in crime generally. In relation to this, I have heard expert opinion hypothesize that the public may well perceive a general rise in resource offences consistent with the general increase in the crime rate. This observation, although not researched to my knowledge, may have merit and reflect somewhat upon the increased demand for officer supervision of resource use.

I am not aware of any research carried out that has not supported the enforcement of law. Our society functions upon a system of rules, and enforcement of those rules is a natural part of the process.

I do not believe there is much argument that the public supports and expects quality law enforcement in managing its fish and wildlife resources. In recent years, there appears to be a lack of understanding as to exactly what the public expects by way of the level and quality of resource law enforcement. Why this situation prevails needs to be examined. What is evident in fish and wildlife resource matters is the need for an understanding of the variables which affect the demand for service because demand does not always relate to resource issues. For example, complaints near large urban centers often relate more to social issues such as nuisance, trespass, damage to property, obtaining permits and misuse of firearms, while in the remote areas, complaints typically reflect resource matters such as closed season hunting, night hunting, female animals taken, fishing in protected waters etc. Our experience in the field indicates enforcement demand is affected by the level of individual tolerance of a particular activity. We, as managers, must be more appreciative and responsive to this situation.

The practical application of rules, which is the area so sensitive to politicians and administrators, is equally important to the public. Citizens expect laws to be enforced and support active enforcement measures whether they are of a preventive nature or to the extent where violations result in court appearances. They expect, and are entitled to, fair and impartial treatment that is delivered professionally within a sound management perspective. The orderly and fair harvest of the resource is important to the public and in large part affects the acceptability of hunting as a means of resource harvest.

The theme of this Conference is an appropriate one to consider. At a time when pressures on the resource are increasing through industrial and agricultural expansion, world-wide exploration for energy sources, highly mobile user groups, more leisure time—all complicated by a period when intergovernmental problems exist over resource ownership and responsibility, it is important to assure that efforts are indeed consolidated. That idea of consolidation should be extended to the whole delivery system, considering all the macro-and micro-management problems that must be solved.

We are at a critical crossroad in the management of fish and wildlife resources in North America and it is important to understand and anticipate the total spectrum of problems associated with managing the resource. In my judgment, agencies have not directed sufficient effort to understanding human-related problems in managing fish and wildlife resources. The expectations of the public who pay the service cost are important and deserve more attention. Contemporary management involves a number of functional components. Among them are biological science, political acceptance and commitment, community relations, and long and short-term planning strategies. One of these management partners is the law enforcement function which administers the approved legislative program. This is the aspect of management which involves the greatest public interaction and requires a high order of commitment over and above dollars and numbers.

It is the responsibility of resource directors to assure that service to the public is delivered professionally and at a level that satisfies reasonable public expectation. Let us all, in the process of consolidating efforts, commit ourselves to better understanding all management problems and respond to them with meaningful commitment. More information is needed to learn about the nature of the people we serve. In that regard, I fear that if we do not approach the task of management with greater recognition of the public's needs and service expectations, we may, by abdicating some areas of responsibility, lose them. That, in my judgment, would contribute nothing to the development of useful solutions to the complex management problems we have today.

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Kaminuriak Caribou Herd: Interjurisdictional Management Problems

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Introduction

The Kaminuriak caribou (*Rangifer tarandus groenlandicus*) herd is named after a lake in its traditional calving grounds in the east-central Keewatin Region of the Northwest Territories. The herd traditionally winters in the tundra of the southeastern Keewatin and in the forests of northern Manitoba. Every year, residents of as many as eight Northwest Territories and Manitoba communities hunt this herd for food. Occasionally, Native hunters from northeastern Saskatchewan who normally depend on caribou from the Beverly herd take caribou from the Kaminuriak herd (Figure 1).

Management of the Kaminuriak caribou herd must involve the coordinated efforts of five government agencies. The herd spends time in Manitoba, Saskatchewan, and the Northwest Territories. Because the herd crosses provincial boundaries, the Canadian Wildlife Service has an interest in its welfare, and in the past has sponsored considerable research on these caribou. The federal Department of Indian and Northern Affairs, which is the department entrusted with the

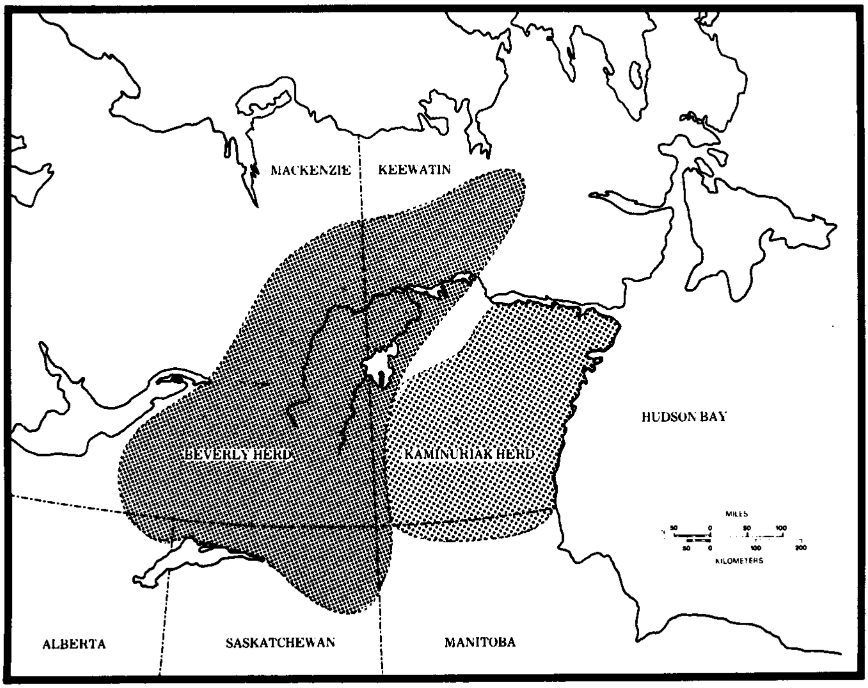

Figure 1. Present range of Kaminuriak and Beverly caribou herds.

welfare of the Indian and Inuit caribou eaters, and which, strangely enough, manages most of the habitat upon which caribou walk, has also involved itself in Kaminuriak caribou management.

Our ability to manage the Kaminuriak herd is presently strained by a decline of this caribou population to the point where its usefulness to Inuit (Eskimos) and Indians is in jeopardy, by the lure of rich mineral deposits in the Keewatin, and by the politics of Native claims to land and wildlife. As a system under strain readily exhibits its strengths and weaknesses, this is an opportune time to examine inter-jurisdictional caribou management in Canada and to profit from lessons learned.

The Problem

The Caribou

The results of Canadian Wildlife Service research in the 1950s and 1960s indicated that the Kaminuriak population was declining rapidly from a 1950 level of 120,000. The 1968 estimate was 63,000; in 1977 it was 44,000. The average rate of decline was at least 4 percent per year (Figure 2).

As the Kaminuriak population decreased, the herd's range also decreased. Before 1955, the Kaminuriak caribou regularly wintered in a large area extending from the extreme southeastern Keewatin Region to a point in Manitoba not far north of Lake Winnipeg (Banfield 1954). Constriction of winter range had begun

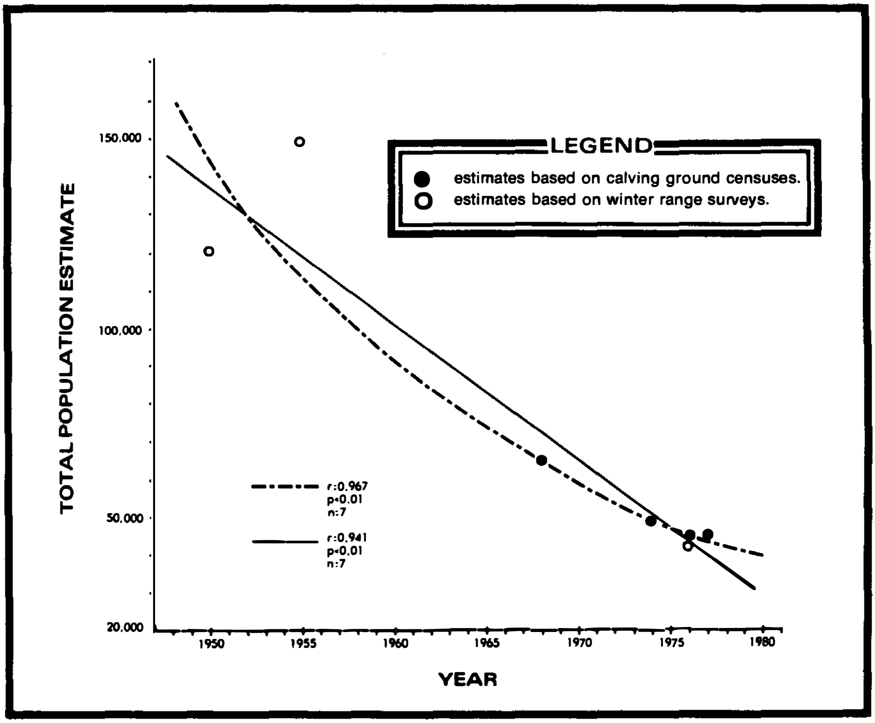

Figure 2. Total population estimates of the Kaminuriak herd.

by the late 1960s and continues to this day. Since 1973–74, the herd has seldom wintered south of the Manitoba border and then only in relatively small numbers (Figure 3, Heard and Calef in press). During 1975–76 and 1976–77, a large part of the herd wintered on the tundra near Baker Lake, Keewatin Region. This is the first time winter use of this range by more than a few small bands from this herd has been reported (Heard and Calef in press).

Although the use of winter range has not been constant since 1955, fidelity to calving areas has been relatively high, at least since 1968 (Figure 4) and probably since the late 1940s (Banfield 1954). The Kaminuriak caribou calve southeast of Baker Lake in an 8,000 km^2 (3,000 sq. mi.) area.

Calef (1974) noted that most caribou populations in North America have maintained a relatively constant density over the past three decades by altering range

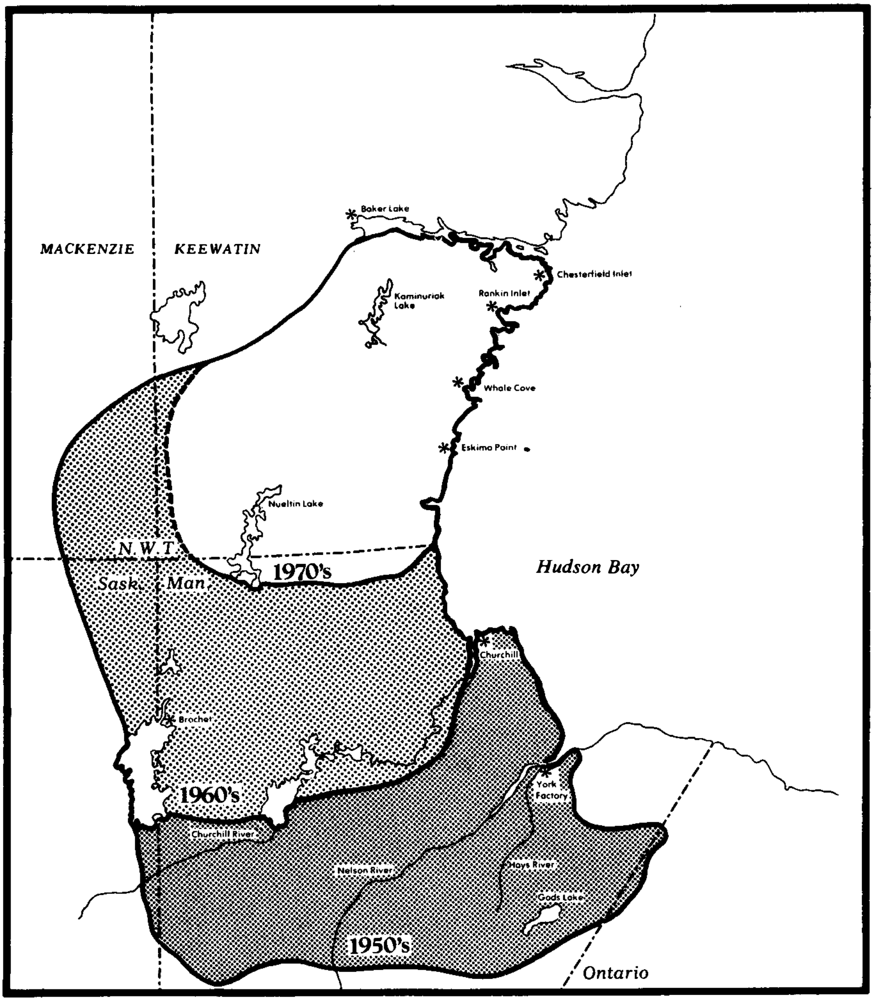

Figure 3. Range of the Kaminuriak herd in the 1950s, 1960s and 1970s.

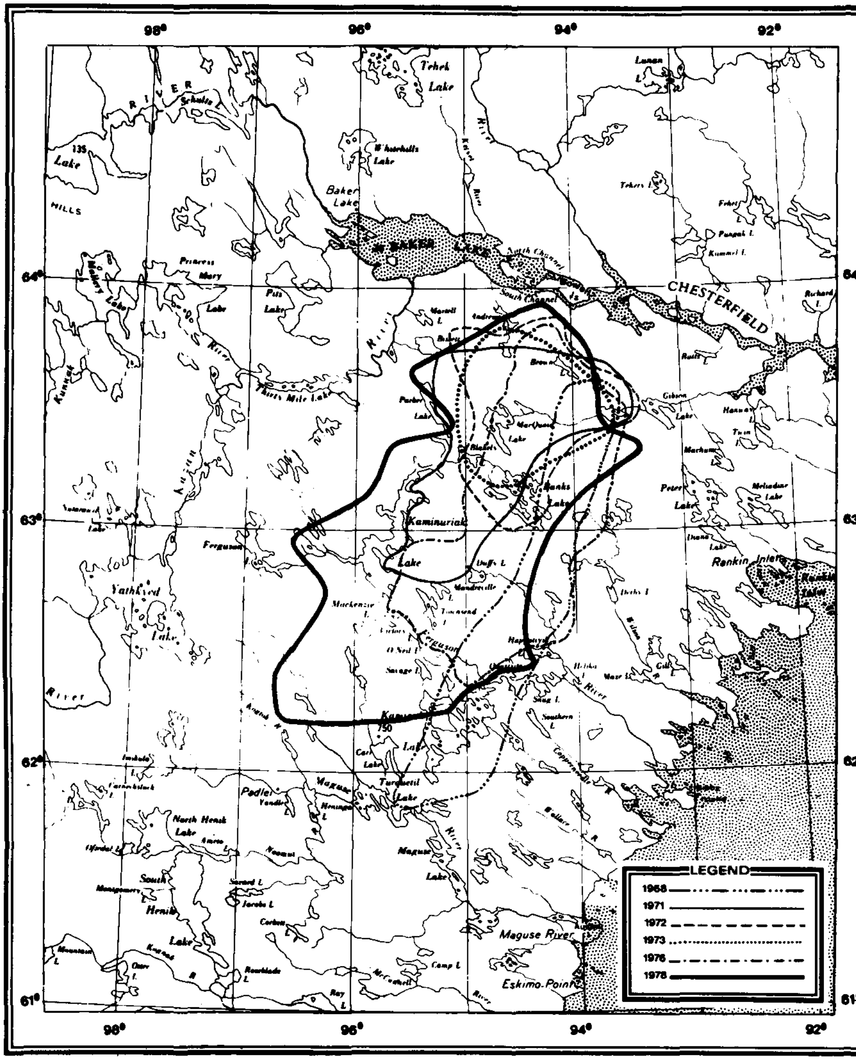

Figure 4. Representative locations of the Kaminuriak herd calving grounds.

size when herd sizes fluctuated. Thus, constriction in total range can be used as evidence of population decline.

Heard and Calef suggest a simple explanation for the decline. Since 1968 natural mortality and hunter kill have exceeded recruitment. Natural mortality is estimated at 8.5 percent per year. The average recorded hunter kill over the past nine years has been 3,000 per year, or about 7 percent of the present herd size. Since the average annual recruitment is 10 percent, the herd may now be declining at a rate greater than that shown in Figure 2 (Heard and Calef in press).

Biologists and Managers

Banfield (1954) and Kelsall (1968) were among the first to alert managers to a widespread decline in Northwest Territories caribou populations. Their warnings led to the designation of barren-ground caribou as an endangered species under the Northwest Territories Act. An intensive wolf control program was implemented during the winter of 1951–52. Although it lasted until 1963, there were no caribou censuses done to measure the program's success.

Despite the fact that no censuses had been done, a biologist publicized an opinion in the mid-1960s that some Northwest Territories caribou populations were approaching such high densities that overuse of their ranges seemed imminent (Ruttan 1965 and 1967). This opinion, plus strong pressure from non-Native sport hunters significantly influenced the caribou management program of the NWT government. There was no evident concern about declining caribou populations in 1971. The resident sport hunter bag limit remained unchanged at five, and legislation was enacted by the NWT government permitting commercial sale of caribou meat from some herds.[1]

In 1971, a Canadian Wildlife Service biologist published his thesis that the numbers of barren-ground caribou in northern Canada had changed only slightly between 1955 and 1967, and had not declined rapidly as others had reported (Parker 1971). But it was not until provincial and territorial biologists analysed the 1976 and 1977 population estimates that they were able to refute this evidence of herd stability, at least as far as the Kaminuriak herd was concerned. Disagreement about the causes of the decline of the herd continues to this day.

Such disagreement among biologists would shake the faith of managers, politicians, and hunters alike. Management decisions have been delayed. Councillors and ministers were not well advised of the need to fund long-term research and continuous monitoring of caribou populations.

The NWT government did not have a biologist on staff specializing in barren-ground caribou until 1976. In fact, until 1972 when the field staff was increased to two, the NWT government had only one field officer to manage wildlife in the entire Keewatin. Regional headquarters were in Churchill, Manitoba. Until 1973, this situation permitted neither adequate participation by the NWT government in Kaminuriak caribou research and management, nor effective communication about caribou management between wildlife managers and Keewatin hunters.

Manitoba had an active caribou research and management program in the 1950s. A 1959–64 caribou tagging program at Duck Lake is still useful to caribou managers (Miller and Robertson 1967). However in 1961, the caribou management program suffered from loss of continuity when the wildlife branch was swept into a new departmental organization. Caribou management in the early 1970s "was directed at meeting 'minimum management requirements' determined from the Canadian Wildlife Service" research in the late 1960s (Robertson 1977). Perhaps this attitude was fostered by the belief of Manitoba officials that they could not manage the harvest of the Kaminuriak herd because most of it took place in the Northwest Territories.

In Saskatchewan, caribou come under the decentralized jurisdiction of the Department of Northern Saskatchewan. In the mid-1960s, Saskatchewan provided a

[1]No commercial sale of meat from the Kaminuriak herd has ever been permitted.

biologist to work with the Canadian Wildlife Service and Manitoba on research and marking caribou. Throughout most of the 1970s, however, Saskatchewan's involvement with coordinated interjurisdictional caribou research and monitoring decreased. Attention focussed on the Beverly rather than the Kaminuriak caribou which were rarely seen in Saskatchewan. Concern for the Beverly herd was understandable as a shrinkage of its winter range similar to that of the Kaminuriak caribou has been documented.

The Canadian Wildlife Service played the role of advisor to the governments of the Northwest Territories and the Provinces until 1974 when they withdrew in favor of the Caribou Management Group. Until that time their biologists shaped caribou management in northern Canada.

The Department of Indian and Northern Affairs, Indian Affairs Branch, played a significant part in efforts to curtail caribou harvests in the 1950s and 1960s by providing fish nets and meat to affected communities, and sharing in the provincial program to convince Indians to limit their caribou harvests. Funds and staff were also contributed for the Duck Lake tagging operation. In the 1970s however, as program emphases shifted, participation in caribou harvest management decreased.

Politician and Hunter

The legislation pertaining to Kaminuriak caribou reflects the legislator's perception of caribou management and the needs of citizens who benefit from the herd. The Northwest Territories Act, for example, enshrines Indian and Inuit rights to hunt, for food for themselves and their families, all species except those listed as being in danger of extinction. Barren-ground caribou were placed on the endangered list in 1960. Animals on the endangered species list are the only species which the NWT government can effectively manage through harvest control. The same NWT Act, however, places the responsibility of caribou habitat management in the hands of the Department of Indian and Northern Affairs, the department that also manages industrial development in the North.

The Department manages caribou habitat largely through Land Use Regulations in Land Management Zones. In 1975, the Department responded to an increase in the intensity of mineral exploration activities by including the Keewatin in its Management Zone scheme and assigning a Land Use inspector to the region.

The Department of Indian and Northern Affairs, which administers the overriding legislation in the Territories, also shares responsibility with the NWT government for the well being of the Inuit. Therefore, its minister wields considerable influence in discussions about harvest quotas which may be imposed under NWT wildlife regulations.

Neither Manitoba nor Saskatchewan have any legislation to limit caribou harvest by Indians whose right to hunt for food on unoccupied Crown land is protected by treaties and by the British North American Act. Persuasion rather than legislation must be used to control harvest by Indians in these provinces.

The Department of the Environment recently determined that it is relatively powerless to act to protect caribou against hunting by Indians and Inuit without the concurrence of the Department of Indian and Northern Affairs. The Department of the Environment cannot serve the role played by the United States Fish and Wildlife Service—ultimate guardian of the nation's wildlife.

In Manitoba, Saskatchewan, and the NWT, recreational hunting of Kaminuriak caribou is insignificant because there are few sport hunters. Nevertheless, in 1978 the NWT quota under the sport hunting license was reduced from five to two caribou per hunter. In Manitoba, sport hunting of caribou is prohibited. In Saskatchewan, resident sport hunters can kill two caribou per year north of 58°N latitude. Metis and nonstatus Indians (not covered by treaty) are issued a maximum of six caribou permits per family per year, depending on their food requirements.

Thus for all practical purposes, caribou are harvested only by Metis, Treaty and nonstatus Indians living in or near Indian communities, and Inuit. Because of Native hunting rights protected by treaties and the Northwest Territories Act, and because Native land claims and aboriginal rights are salient political issues of the 1970s in Canada, the control of hunting automatically becomes an important threat to the welfare of any politician. This is particularly true in the Northwest Territories where the Inuit Tapirisat of Canada (ITC), the national Inuit political institution, is negotiating a claim of aboriginal rights to land and wildlife north of the treeline. One of its affiliates, the Keewatin Inuit Association (KIA), represents those in the NWT who would be affected by Kaminuriak caribou harvest restrictions. Their executive understandably presses for lengthy consultation with Native hunters before laws are changed, and encourages government managers to allow Inuit to manage their own game in their own traditional way. At this point in history, Federal and Territorial legislators are bound to listen to Inuit voices.

Restrictions on industry are more politically palatable than restrictions on hunters. The Keewatin Inuit Association and the Baker Lake Hunters and Trappers Association flexed their muscles in 1977, forcing the suspension of mineral exploration activities in a vast area around Baker Lake when caribou are present. Responding to KIA's claim that such activities threaten the welfare of caribou, the Minister of Indian and Northern Affairs stopped issuing land use permits in the late winter of 1977 in the 78,000 km^2 (30,000 square miles) area. This freeze was extended to the spring of 1978 when the Hamlet of Baker Lake obtained an interim injunction against the issuance of prospecting and land use permits in the Baker Lake area (Darby 1979). Further court action is pending.

In defense of the beleaguered caribou, there resulted from KIA's intervention a flood of money and manpower, the like of which has rarely resulted from a wildlife manager's plea. Literature was searched, and caribou movements were monitored as the animals moved in and out of the land-freeze area. Only in the absence of caribou were prospectors allowed into the area. Monitoring and research will continue at least through the summer of 1979.

This flurry of activity overshadowed the main problem with caribou—their decline for reasons unrelated to the activities of the mineral industry. Nevertheless, the KIA spawned a new policy of special land management zones and land use permit conditions designed to protect Kaminuriak and Beverly caribou. The policy was announced in April 1978, and is applauded by wildlife managers as a step that should be taken in favor of all caribou herds.

The situation in Manitoba differs markedly. The Indians of northern Manitoba have been without the caribou they used to kill at the average rate of 200 per family per year (Robertson 1977, Miller and Robertson 1967). They and the Manitoba government are more receptive to a quota on caribou harvest to effect the recovery of the population. The Indians of northern Saskatchewan, as well as the Saskatchewan government, seem to be bystanders to the political scene. The Indians now hunt caribou of the Beverly herd almost exclusively, and cannot be further affected by the decline of the Kaminuriak population. Their contribution to discussions and activities surrounding the Kaminuriak herd have, until this year, been minimal. The wildlife managers of Saskatchewan do, however, have cause for concern as people eye the Beverly caribou as an alternate source of food to the troubled Kaminuriak herd.

The Hunter's Viewpoint

Imbedded in the rhetoric of northern politics is a description of the Indian and Inuit as natural conservationists who are proper custodians of their own wildlife resources. According to this scenario, the southern-trained wildlife manager is an unnecessary and frequently unwanted obstacle. The wildlife manager, on the other hand, commonly sketches the northern Native as the myopic, selfish cause of wildlife population declines, and he cites a number of authors as witnesses (Banfield 1954, Kelsall 1968). This clash of viewpoints is symptomatic of the fact that our conservation ethic, founded in Europe in the 16th century, is relatively new to the barren-ground caribou hunter. In the Keewatin, exposure to the European concept of wildlife conservation has been confined to the latter half of this century. Hunters who, until recently, could not significantly influence the future of a caribou population have difficulty accepting the suggestion that suddenly they have become poor stewards of a resource with which they have been living harmoniously for many centuries. Science is not a part of the Indian or Inuit tradition.

The Inuit of the Northwest Territories are still largely dependent on caribou for food and sleeping skins. For Indians too, caribou are still an important source of food although they no longer use skins for bedding and clothing as a common practice. A decline in a caribou population or a shift in range is a matter of serious concern to these people. Camps and villages became established in locations which permitted easy access to migrating caribou. When caribou failed to appear, these settlements were abandoned or their residents suffered. Inuit living in the Garry Lake area of the Back River did not move when caribou failed to appear in the winter of 1957–58, and people starved. The dependence of Native hunters on caribou is a fact that will shape whatever management schemes we may devise to bring about the recovery of the Kaminuriak caribou population.

The population of caribou hunters is increasing as a result of high birth rate and infant survival. Also, since the late 1960s the native Keewatin hunter has become so mobile with motor toboggans and aircraft that game can no longer elude him and his high-powered rifle. However, attitudes and laws have not changed to accommodate population growth and the hunter's new ability to dictate the welfare of wildlife.

The northern Canadian wildlife researchers and managers have done relatively little to change Native viewpoints. The biologist usually arrives in the North, conducts his surveys and research with little or no involvement with the Native hunter, then returns south and publishes data in English for the converted to read. A wildlife crisis may bring on a burst of communications effort aimed at Native hunters, but the effort is not sustained.

Manitoba and the Canadian Wildlife Service pioneered education about proper management of eastern caribou in the 1950s with publications for the layman and, more effectively, a user–manager dialogue. The results of Manitoba's efforts clearly showed in voluntary reduction of caribou harvest and less wastage of caribou meat by the Chipewyan hunters. The chiefs and band councillors took active roles in harvest management in the mid-1950s (Robertson 1977), and this responsible attitude is evident today.

Until recently, no major effort had been made by wildlife managers to engage in a dialogue on caribou research and management with the Inuktitut speaking hunters of the Keewatin. Now, exposed to a flood of information about their caribou and other wildlife, and compelled to respond to the managers with whom they have demanded consultation, Keewatin Inuit seem confused by the clash of new and old beliefs. They protest against prophesies of doom for caribou when thousands of the gregarious beasts swirl around the villages. They blame prospectors, biologists, geologists, Manitoba Indians, fires and major shifts in caribou range. They are suspicious of efforts to collect harvest data, thinking it might be used against them through imposition of quotas and seasons. These views, echoed in the chambers of the Territorial Council by the Native majority, are amplified by the government's newfound sensitivity to Native concerns.

The Solution

The Caribou Management Group

The Canadian Wildlife Service and the governments of Saskatchewan, Manitoba, and the Northwest Territories formed the Caribou Management Group in 1971 for the purpose of coordinating research on, and management of, the Kaminuriak and Beverly caribou herds. Recently, the Department of Indian and Northern Affairs became a Group member because of its interest in Indian and Inuit welfare and in caribou habitat. The members are program managers or division heads. They, in turn, formed a Technical Committee of research biologists to advise the Group. The Group and Technical Committee meet irregularly as required, but usually several times a year. Research and management proposals are discussed by the Group, and budgets are formulated and approved by the members.

The most severe test the Group has faced is the current Kaminuriak caribou problem. Once the Technical Committee presented its recent confirmation of the population decline and gave its projection of a continued decline due largely to over-hunting, the Group designed and implemented a short-term response.

For the following reasons, an information and education program was to be the major line of attack:

1. If the reasons for laws are not recognized or are poorly understood by Native hunters, they will be difficult and expensive to enforce. Hunting restrictions championed by the hunters themselves are most effective.
2. The Canadian Wildlife Service and the governments of Manitoba and Saskatchewan have no legislation in place which they can employ to restrict hunting. They cannot complement season and quota restrictions imposed by the Northwest Territories. Inuit from the Keewatin would feel unfairly fet-

tered in view of the freedom of Indian hunters to take Kaminuriak caribou south of 60°.
3. The support of legislators is essential, and of Native political organizations desirable, before regulations on caribou hunting can be changed.

The announced goals of the information and education program are simply to inform Native hunters and their political representatives about recent research results, to interpret these results for them, and then to solicit suggestions from them about how to properly manage the herd. Seasons or quotas would not be discussed, but genuine efforts would be made to obtain the hunter's viewpoint. The ideal result would be voluntary curtailment of harvest. There is precedent for such self-imposed restrictions among the Inuit of the Belcher Islands and Southampton Island, NWT, and the Indians of northern Manitoba.

The ministers of the five jurisdictions and the Northwest Territories Executive Committee were thoroughly briefed about the Kaminuriak situation in late 1978. During its February 1979 session, the Territorial Council received a comprehensive briefing about all NWT caribou herds and particularly the Kaminuriak herd. By September 1978, all eight communities which hunt the Kaminuriak caribou had been appraised of the problem by biologists and wildlife officers. The Territorial Wildlife Service used brochures and a synchronized sound and slide show, as well as officers familiar to the hunters, to deliver the message. Hunters and trappers associations in the NWT facilitate delivery of such information. These associations, and Manitoba and Saskatchewan hunters, were asked to select delegates to a government sponsored meeting of representatives from all user communities.

The initial meetings certainly achieved the intended result. Hunters began talking with each other about the caribou problem to the point where the topic dominated meetings convened for other purposes. Despite strong opposition from suspicious politicians, delegates traveled to a conference of hunters in Thompson, Manitoba.

The Thompson conference was between hunters and biologists only. No one from agency headquarters and no politicians were invited. Once delegates accepted the fact that they would not be expected to make decisions on behalf of their home communities, they relaxed and gave frank appraisals of the Kaminuriak situation. Discussions were in five languages, consecutively translated, so proceedings were slow. The biologists present were shaken by the reluctance with which Inuit hunters acknowledged that there even was a problem. Most delegates refused to accept the statement that overhunting was a cause of population decline, and they gave varied and imaginative reasons for the problem. Nevertheless, the hunters left the meeting with a broadened perspective of caribou harvest and the nature of dependence of other communities on the shared caribou herd. They all called for a second meeting to focus on the major issues of caribou management.

The proceedings of the conference were analyzed by the Caribou Management Group, and plans were made for the second stage of the information and education program. Tape recordings and minutes of the Thompson conference were distributed to the communities. They were disussed on radio broadcasts and during meetings. Manitoba and the NWT produced slide talks about the Thompson meeting to be shown in each community by wildlife officers. A team of Manitoba and Northwest Territories biologists was formed to carry the message of the caribou problem to each community. Exchange visits to the Keewatin and Manitoba have been planned to help hunters understand the issue. A second hunter–biologist meeting was scheduled for Baker Lake in April 1979. A Management Group meeting was slated for Ottawa in late February to which senior Federal Government officials and leaders of Native political organizations were invited for a briefing and discussion on progress to date and plans for future action.

A third and final user–manager conference will be held in the fall of 1979. Final recommendations will be aired and management decisions will be made shortly after the end of the meeting. Decisions may involve new legislation and alternative food sources for caribou hunters. Final decisions will, no doubt, be political responses to recommendations of managers.

Conclusions

The Kaminuriak situation warns us not only about the pitfalls of managing a caribou herd which migrates across our arbitrary political boundaries, but also about caribou management throughout Canada. Programs of caribou population monitoring and research have been inadequately designed and funded. Jurisdictional problems have crippled concerted research and management efforts and the methods of collecting kill statistics have been inconsistent and ineffective.

The recent briefings of councillors and ministers about the Kaminuriak problem and caribou management in general may help gain financial support. Management agencies are now exploring new techniques in population monitoring. Monitoring of NWT caribou herds is now part of a budget base and will be done on a regular schedule. The NWT Wildlife Service is making an effort to improve its hunter kill statistics. The success of this effort will be directly related to the success of our new public information program. We are beginning to make conservation education materials about caribou available to schools and to the general public, and research and management data in Inuktitut and popular English is now being published for use in the communities.

These improvements will benefit caribou management in the years ahead, but the Kaminuriak problem is too serious for us to await the results of these long-term solutions. Action is needed now. If we do not act together immediately to effectively reduce the numbers of caribou killed by hunters and wolves, we are condemning this herd to continued decline and possible extinction.

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Can Ducks Be Managed by Regulation?

An Examination of Harvest and Survival Rates of Ducks in Relation to Hunting

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Introduction

Duck hunting is a traditional recreational activity that annually attracts the participation of more than 2 million hunters in the United States. During recent years (1961–74) U.S. hunters have bagged from 4.2 to 13.9 million ducks annually (Martin and Carney 1977) from fall populations that are estimated to have ranged from 49 to 102 million in size (unpublished data, on file at office of Migratory Bird Management).

The duck populations that provide these harvests (retrieved kill) are of value and importance not only to hunters; they are a great attraction and a source of enjoyment to a large body of nonhunters as well. For this reason, the management of ducks is a matter of interest and concern to a sizeable public.

One of the most visible aspects of duck management is the regulation of hunting. While not necessarily the most important aspect of management, it is one that attracts much attention and sometimes much controversy, not only among the public but also among waterfowl managers.

The size of the fall population of ducks is influenced greatly by habitat conditions on the breeding ground. During years when water is abundant on the breeding grounds, recruitment usually is much higher than in years of drought. The proportion of the fall population taken by hunters varies considerably among species. Hunting is a major cause of mortality in mallards (*Anas platyrhynchos*), and has accounted for about one-quarter of the total population in some years. In contrast, only a small fraction of the population of blue-winged teal (*Anas discors*) is taken by hunters each year.

In our view, there is little question about the need to regulate the hunting of ducks. However, the effectiveness of regulations in controlling size of harvest is much less apparent, as is the impact of shooting upon the population status of key species. Over the years, duck hunting regulations in the United States generally have been conservative because of concern over the adverse effects that excessive hunting kill might have upon the resource. To a considerable degree, this conservative approach still prevails. However, in recent years, analyses of mallard banding and other population records have led to the development of new viewpoints and indicate the need to reexamine this important question. For example, recent studies have failed to demonstrate the clear and direct relationship between hunting mortality and total mortality formerly thought to exist in this heavily-hunted species (see Anderson and Burnham 1976). They suggest, instead, that hunting mortality is largely compensatory to other forms of mortality. These findings are not yet fully understood or accepted and their meaning for waterfowl management is still not entirely clear.

In this paper, we briefly describe the types of regulations applied to duck hunting in the U.S. and discuss some of the results and some of the problems encountered in efforts to evaluate their place in the management scheme. We examine the complex question of the effect of hunting on survival rates, particularly in regard to the mallard. In this connection we discuss and expand on some previous findings and conclusions by Anderson and Burnham (1976).

Methods Used to Regulate Harvest

The establishment of regulations for hunting ducks and other migratory birds in the U.S. is a responsibility of the Federal Government. This authority is based on international migratory bird treaties with Canada, Mexico, Japan, and the U.S.S.R.—the earliest dating back to 1916. The Federal responsibility is exercised chiefly through the U.S. Fish and Wildlife Service in the Department of the Interior. In practice, it is a responsibility that is shared to a considerable degree with the state governments. Thus, the Service works most closely in these matters with Canada and Mexico, who share many of the same bird populations, as well as with state conservation agencies.

Duck hunting in the U.S. and Canada is subject to a large body of regulations that have evolved chiefly over a period of 45 years beginning in 1935. When compared to the situation in other countries where duck hunting is important, our regulatory efforts must be regarded as intensive and complicated. In this regard they reflect the general complexity of game regulations in North America.

The regulations may be separated into two general categories. The first includes so-called basic regulations that continue from year to year with little or no change. Included in this category are stipulations of methods by which ducks may be legally taken (e.g. prohibitions on the use of live decoys, bait, and certain types of weapons), dates within which hunting seasons must be set, hunting zones within states, daily shooting hours, etc. The second category relates chiefly to general and specific bag limits, length of hunting seasons, special hunting seasons and other regulations frequently subject to annual change in response to changes in duck population and harvest conditions. The following are examples of the various types of regulations.

Hunting Season Frameworks. Framework dates are the earliest and latest permissible dates within which states may select their hunting season. The Migratory Bird Treaty Act requires a closed season for wild ducks from 10 March to 1 September. Framework dates for duck hunting customarily are from 1 October through 20 January.

Generally, states attempt to choose a period within the framework that coincides with an abundance of ducks. Since this relates to migration, northern states select opening dates early in the framework, mid-latitude states at an intermediate time, and southern states later in the framework. Hunting pressure on breeding populations in the north may be reduced by a framework which delays the earliest possible opening date. Advancing the date for the end of the season reduces hunting pressure on wintering populations in the south.

Season Length. Duck harvest may be increased or reduced by varying the length of the hunting season. Shortening the length of the season is more effective as a harvest limitation in mid-latitude and southern states. In northern states, harvest tends to be limited by the brief period of time that ducks are available. Currently, the longest seasons are allowed in the Pacific and Central flyways and the shortest in the Mississippi and Atlantic flyways. These differences reflect varying duck populations and hunting pressures among flyways.

Split Seasons. Federal regulations allow states to split the hunting season into two separate time periods to take advantage of two or more peaks in duck abundance. There appears to be no consistent pattern of increased harvest caused by split seasons as compared to continuous seasons (Martin and Carney 1977).

Special Seasons. Special seasons and bag limits are allowed for certain species or groups of ducks for which additional harvest opportunity can be provided without adverse effect on their populations. Special seasons generally are in addition to regular seasons and may occur outside of the usual framework dates. An example is the special September season focused largely on blue-winged teal that migrate through the U.S. before regular hunting seasons begin. Green-winged *(Anas crecca)* and cinnamon teal *(Anas cyanoptera)* also are included. Only states not considered important production areas are permitted the special teal season.

Another example is special sea duck seasons for scoters (*Melanitta* sp.), eiders (*Somateria* sp.), and oldsquaws (*Clangula hyemalis*) outside of the regular season in the coastal waters of Atlantic Flyway states. The length of this season is extended beyond that of the regular season.

Zoning. Zoning involves the delineation of two or more areas within a state in each of which hunting seasons may be set independently of other areas. The objective of zoning is to provide a more equitable distribution of harvest opportunity among hunters in a given state or geographical area. Zoning currently is being studied to determine whether it results in increased harvests beyond traditional levels.

Shooting Hours. With the exception of special September teal seasons, daily shooting hours in the United States run from one-half hour before sunrise to sunset. The sunrise opening is required for the special teal season primarily to protect wood ducks (*Aix sponsa*), a species very active just before sunrise, and one that might be mistaken for teal at that time. In Canada, with few exceptions, shooting hours are from one-half hour before sunrise to one-half hour after sunset. In Mexico, there are no Federal restrictions on shooting hours.

Daily Bag Limit. Duck harvest can be regulated by adjustment of the number of ducks the hunter is allowed to bag per day. Currently, two basically different methods are used to control the daily harvest of ducks.

The traditional fixed bag regulation defines the number of ducks allowed per day. The number may be variable by species and/or sex. The take of ducks judged in need of greater than normal protection may be reduced to a number less than the combined bag limit (restriction) and the take of ducks requiring less than normal protection may be increased to a number greater than the combined bag limit (bonus).

The point bag regulation assigns lower point values to ducks which need less protection and higher point values to ducks requiring greater protection. The bag limit under the point system is calculated by adding the point values of the ducks shot. In recent years, the bag limit is obtained when 100 points is reached.

Effects of Hunting Regulations on Duck Harvest

Hunting regulations are used to provide a degree of control over size and rates of waterfowl harvest. It thus is extremely important to determine the relationship between various hunting regulations and harvest. In most of this section we will briefly examine the relationship between regulations and harvest of mallards. We have chosen to concentrate on the mallard because it is the most abundant duck in North America and because the U.S. Fish and Wildlife Service has directed a major research effort toward understanding its population ecology (see the reports of Anderson and Henny 1972, Pospahala et al. 1974, Anderson 1975, Anderson and Burnham 1976, Martin and Carney 1977).

The effects of various historic regulations on the size and sex composition of the mallard harvest have been examined in detail by Martin and Carney (1977). They have summarized apparent effects of such regulations as daily bag limits, season length, season dates and opening day characteristics on the size of the mallard harvest. Despite their tentative conclusions, however, multiple correlation analysis of the relationship between mallard harvest and various aspects of regulations yielded results that were "largely inconclusive" (Martin and Carney 1977:73).

Relationship Between Regulations and Mallard Band Recovery Rates. The interactions between the various components of hunting regulations and the fact that they are seldom varied independently tend to obscure the relationship between any single regulation and duck harvest. However, it is possible to consider the various components of regulations simultaneously and to categorize years of "restrictive," "average," or "liberal" hunting regulations. In order to examine the effect of regulations on mallard harvest rate, Martin et al. (1979) chose years of extreme regulations and contrasted band recovery rates (indices to harvest rates) for years characterized by restrictive versus liberal regulations. Recovery rates from the years of restrictive regulations (1962, 1965, 1968) were significantly ($P < 0.01$) lower than those from years of liberal regulations (1964, 1970). Hunting regulations during the 1970s generally have been considered to be more liberal than those of the 1960s. Therefore, we repeated the analysis of Martin et al. (1979) using the same set of restrictive years (1962, 1965, 1968) but a different set of more recent liberal years (1970, 1974, 1975). The liberal years were characterized by larger bag limits and longer seasons than the restrictive years.

Data for this and subsequent analyses were obtained from the files of the Bird Banding Laboratory, Office of Migratory Bird Management, Laurel, Maryland. We used records of normal, wild birds banded during the preseason (July-September) period and "shot" or "found dead" during the period September

1—February 15. Data were summarized by minor reference area of banding (after Anderson and Henny 1972). Survival and recovery rates were estimated using the methodology and algorithms presented by Brownie et al. (1978). In order to test for differences between survival or recovery rates, we employed z test statistics for individual reference areas. For details on this test see Brownie et al. (1978:180–182). Composite test statistics over all reference areas were computed as:

$$z = \frac{\sum_{i=1}^{n} z_i}{\sqrt{n}}$$

where n is the number of reference areas involved and z_i is the test statistic for area i. Both z and z_i are distributed as Normal (0,1) under the null hypothesis.

In our contrasts of recovery rates for restrictive years of the 1960s (1962, 1965, 1968) versus those from liberal years of the 1970s (1970, 1974, 1975), we used one-tailed hypothesis tests. Composite test statistics (10 reference areas were used) indicated that recovery rates in liberal years were significantly higher ($P < 0.05$) for all age–sex classes (adult male $z = 2.25$, adult female $z = 3.35$, young male $z = 3.02$, young female $z = 5.45$). Thus we conclude that hunting regulations are effective in influencing recovery rates and presumably harvest rates.

Relationship of Hunting to Mallard Survival Rates

We believe that the information presently available, including that just discussed, confirms previous conclusions that there is a direct relationship between regulations and the size and rate of harvest. Now we want to examine the larger issue concerning what effect, if any, this has on population status.

Here we are interested in two general questions: (1) do survival rates vary from year to year, and (2) do changes in hunting regulations or harvest rates seem to be associated with changes in survival rates?

The questions we address have been investigated by Anderson (1975) and Anderson andBurnham (1976). We will discuss some of their results and update some of their analyses on the basis of 5 additional years of banding and recovery data accumulated since their work was completed. These new data are of particular interest because of the relatively high harvest rates occurring during the 1970s.

Although we have chosen to concentrate on survival rates in this paper because of their presumed relationship to regulations, we do not wish to imply that reproductive rates are of lesser importance. Any judgment about the well-being or status of a duck population ultimately requires knowledge on both reproduction and survival.

Annual Variation in Survival Rates

Before it is reasonable to seek causes of variation in survival rates, it is necessary to demonstrate that these rates do vary annually. We might expect survival probabilities of mallards to vary from year to year, but we must be able to detect this variation if the subsequent analyses are to have meaning.

Adult data were tested using the likelihood ratio test of Model 2 vs. Model 1 (see Anderson and Burnham 1976:59-60, Brownie et al. 1978). Model 1 assumes that both recovery and survival rates vary over the years, whereas Model 2 assumes that recovery rates vary but that survival rates remain constant. Results of these tests are presented in Table 1. Only two individual reference areas showed significant x^2 values for males. However, overall test statistics indicated that survival rates varied over time for both males ($P < 0.05$) and females ($P < 0.01$).

A more powerful test with both young and adult data was conducted using the likelihood ratio test of Models H_{02} . H_1 (Brownie et al. 1978). Model H_1 assumes that both recovery and survival rates vary, but Model H_{02} asssumes that recovery rates change but survival remains constant. Test results are presented in Table 2. Several individual reference areas show significant test statistics, and the overall statistics indicated that survival rates varied over time for both males ($P < 0.01$) and females ($P < 0.01$). We conclude from these tests that mallard survival rates vary among years.

Relationship Between Harvest Rates and Survival Rates

Having demonstrated that survival rates vary over time, it is important to ask whether this variation is associated with changes in hunting regulations or harvest rates. Anderson and Burnham (1976) used several methods to investigate this critical question. One method involved a comparison of mallard survival rates in years of "restrictive" versus "liberal" hunting regulations. They compared survival rates from 3 years of restrictive regulations (1962, 1965, 1968) with those from 2 years of liberal regulations (1964, 1970) and found no evidence of higher rates during the restrictive years.

Because of the more liberal regulations of recent years we contrasted survival rates from restrictive years (1962, 1965, 1968) with those from recent years of liberal regulations (1970, 1974, 1975). As indicated earlier, composite test statistics for all areas tested indicated that recovery rates were significantly ($P < 0.05$) greater during the liberal years than during the restrictive years for all age–sex classes, suggesting that these choices were reasonable.

Test statistics for the liberal versus restrictive year survival rate contrasts are provided in Table 3. One-tailed tests were used. Two of the individual test statistics were significant at the 10 percent level ($0.05 < P < 0.10$), and all remaining statistics were non-significant. However, it should be noted that the power of these individual tests generally is low and that a number of reference areas and age–sex classes were not included because of insufficient data. Composite test statistics for each age and sex class from the different areas with adequate information were non-significant. In fact, for all age–sex classes other than young males, the mean difference between survival rates indicated higher survival estimates during years of liberal regulations. A composite test statistic for all age–sex classes was computed as $z = 0.72$, and this also was non-significant. Thus, we are unable to reject the null hypothesis that survival rates were the same during these two sets of years corresponding with extreme regulations. There was no evidence of high survival rates during years of restrictive regulations.

Table 1. Results of testing the null hypothesis that recovery rates of adult mallards vary from year to year but that survival rates are constant, versus the alternative hypothesis that both survival and recovery rates vary from year to year.

	Males				Females			
	Model 2 vs. Model 1[a]				Model 2 vs. Model 1			
Minor reference area	Years	d.f.	X^2	P^b	Years	d.f.	X^2	P
NE Alberta (023)	1966–69	3	2.79	0.426	1966–69	3	3.09	0.379
SW Alberta (031)	1966–75	9	8.11	0.524	—	—	—	—
NE Southern Alberta-SW Saskatchewan (041)	1961–75	14	45.11***	0.000	1962–75	13	22.20*	0.052
SE Saskatchewan (051)	1965–70	5	7.84	0.165	1964–70	6	2.18	0.903
SW Manitoba (061)	1967–75	8	12.42	0.134	1967–75	8	11.51	0.174
W Washington (091)	1964–72	8	4.59	0.800	—	—	—	—
E Washington (092)	1969–73	4	0.99	0.912	1960–73	13	16.84	0.207
W Oregon (093)	1959–65	6	5.38	0.496	1959–62	3	2.33	0.506
E Oregon (094)	—	—	—	—	1959–72	13	22.78**	0.044
N California (101)	1949–55	6	6.52	0.368	1959–75	16	21.36	0.165
Central California (102)	1951–55	4	2.81	0.589	1952–55	3	0.71	0.870
Idaho (111)	1960–74	14	15.88	0.320	1960–68	9	12.00	0.213
W Montana (112)	1959–65	6	7.42	0.284	—	—	—	—
Nevada (113)	—	—	—	—	1961–65	4	1.22	0.875
E Montana (121)	1957–68	11	22.49**	0.021	1958–68	10	25.49***	0.004
E Colorado (126)	1959–75	16	10.51	0.839	1969–75	6	9.66	0.140
S Central Colorado (127)	1963–75	12	12.65	0.395	1963–75	12	23.13**	0.027
E North Dakota (131)	—	—	—	—	1959–75	16	10.18	0.857
E South Dakota (132)	1960–73	13	11.25	0.590	1960–73	13	12.80	0.464
W Minnesota (133)	—	—	—	—	1957–75	18	27.57*	0.069
Michigan-N Ohio-N Indiana (143)	1960–75	15	13.18	0.588	1958–75	17	34.45***	0.007
Western Mid-Atlantic (151)	1960–75	15	13.69	0.549	—	—	—	—
NE United States (161)	1961–75	14	15.19	0.365	—	—	—	—
All areas		183	218.82**	0.036		183	259.50***	0.000

[a]See Brownie et al. (1978) for model specification.

[b]P is the probability of obtaining a larger X^2 value if the null hypothesis is true.

*$0.05 < P < 0.10$; **$0.01 < P < 0.05$; ***$P < 0.01$

Table 2. Results of testing the null hypothesis that recovery rates of young and adult mallards vary from year to year but that survival rates are constant, versus the alternative hypothesis that both survival and recovery rates vary from year to year.

	Males				Females			
	Model H_{02} vs. H_1 [a]				Model H_{02} vs. H_1			
Minor reference area	Years	d.f.	X^2	P[b]	Years	d.f.	X^2	P
NE Alberta (023)	1966–69	7	5.47	0.603	—	—	—	—
SW Alberta (031)	1961–75	29	36.22	0.167	1966–75	19	21.88	0.290
NE Southern Alberta-SW Saskatchewan (041)	1961–75	29	100.67***	0.000	1962–75	27	39.57	0.056
SW Manitoba (061)	1967–75	17	20.39	0.255	1967–75	17	18.63	0.350
W Washington (091)	—	—	—	—	1966–72	13	8.36	0.819
E Washington (092)	1969–73	9	6.09	0.731	1969–73	9	18.36**	0.031
E Oregon (094)	1959–73	29	53.79***	0.003	—	—	—	—
N California (101)	1957–75	36	63.08***	0.004	1959–75	33	49.73**	0.031
Central California (102)	1951–55	9	11.21	0.262	1952–55	7	15.21**	0.033
Idaho (111)	1962–74	25	24.22	0.507	—	—	—	—
W Montana (112)	1960–65	11	19.99**	0.046	—	—	—	—
E Montana (121)	1962–68	13	20.06*	0.094	1965–68	7	25.02***	0.001
E Colorado (126)	1968–75	15	7.40	0.946	1970–75	11	13.37	0.270
S Central Colorado (127)	1963–75	25	35.96*	0.072	1963–75	25	53.52***	0.001
E North Dakota (131)	—	—	—	—	1960–75	31	21.02	0.911
E South Dakota (132)	1960–69	19	11.20	0.917	1960–69	19	15.85	0.667
W Minnesota (133)	—	—	—	—	1957–75	36	55.48**	0.020
Michigan-N Ohio-N Indiana (143)	1960–75	31	26.15	0.714	1958–75	35	62.11***	0.003
Western Mid-Atlantic (151)	1960–75	31	31.13	0.460	—	—	—	—
NE United States (161)	1961–75	29	30.65	0.382	—	—	—	—
All areas		364	503.68***	0.000		289	418.11***	0.000

[a]See Brownie et al. (1978) for model specification.
[b]P is the probability of obtaining a larger X^2 value if the null hypothesis is true.
*$0.05 < P < 0.10$; **$0.01 < P < 0.05$; ***$P < 0.01$

Table 3. Results of testing the null hypothesis that mallard survival rates in years of liberal regulations (1970, 1974, 1975) were the same as those in years of restrictive regulations (1962, 1965, 1968).

	Adults				Young			
	Males		Females		Males		Females	
Reference area	$\bar{\hat{S}}_L - \bar{\hat{S}}_R$ [a]	z	$\bar{\hat{S}}_L - \bar{\hat{S}}_R$	z	$\bar{\hat{S}}_L - \bar{\hat{S}}_R$	z	$\bar{\hat{S}}_L - \bar{\hat{S}}_R$	z
SW Alberta (031)	−0.18	−1.30	—	—	−0.12	−0.85	—	—
NE Southern Alberta-SW Saskatchewan (041)	0.07	1.22	0.16	1.23	−0.11	−1.16	−0.15	−0.90
E Ontario-W Quebec (081)	—	—	0.02	0.26	—	—	—	—
N California(101)	0.09	1.05	0.17	1.44	0.18	1.64	−0.01	−0.07
E Colorado (126)	0.07	0.74	—	—	—	—	—	—
E North Dakota (131)	0.14	1.68	0.03	0.24	—	—	0.22	1.05
W Minnesota (133)	—	—	−0.00	−0.01	—	—	0.03	0.33
Michigan-N Ohio-N Indiana (143)	0.02	0.20	−0.09	−0.78	−0.06	−0.65	0.05	0.50
Western Mid-Atlantic (151)	−0.14	−1.36	−0.03	−0.34	−0.07	−0.81	—	—
NE United States (161)	−0.01	−0.06	0.01	0.09	0.03	0.36	—	—
Mean	0.06	0.27	0.03	0.27	−0.03	−0.25	0.03	0.18
Composite test statistic z		0.77		0.75		−0.60		0.41

[a] $\bar{\hat{S}}_L - \bar{\hat{S}}_R$ denotes the difference between mean survival estimates for liberal and restrictive years.

Next, we examined the relationship between survival rates and harvest rate indices for adult mallards (see Anderson and Burnham 1976: 31–33). Continental survival rates were estimated by computing weighted averages, where estimates from individual reference areas were weighted by population size as measured in May breeding ground surveys. Only survival estimates of reasonable precision (arbitrarily defined as coefficient of variation less than 0.30) were used. Table 4 includes the number of minor reference areas and the estimated proportion of the North American mallard breeding population to which the survival estimates directly apply. The volume of banding data is much larger for males than females.

We believe that our best estimates of harvest rates are those obtained from banding and recovery data. However, because of the sampling correlation between harvest and survival rates, we could not examine the relationship between these two sets of estimates. Thus, we computed an independent index to harvest rate by dividing the total mallard harvest in the United States (as estimated from the harvest survey) by the total breeding population size (estimated in the May breeding ground surveys). Major limitations of this index include the use of May rather than September population size and harvest in the United States rather than the harvest from both the United States and Canada. The chief virtue of the index is its independence from the survival estimates. Anderson and Burnham (1976) found that the harvest rate index was significantly correlated with harvest rates from banding data for males but not for females.

Continental survival rate estimates and harvest rate indices are presented for adult males and females in Figures 1 and 2. Clear relationships between the two variables are not readily apparent in either of the figures. The adult male plot, in

Table 4. Estimated proportion of the total mallard breeding population for each sex used to compute the continental survival estimates of Figures 1 and 2.

	Males		Females	
	Minor reference areas[a]	Total proportion[b]	Minor reference areas	Total proportion
1961	10	0.27	4	0.05
1962	11	0.33	6	0.07
1963	15	0.48	9	0.13
1964	14	0.31	14	0.32
1965	16	0.45	14	0.33
1966	16	0.64	13	0.44
1967	17	0.61	14	0.56
1968	17	0.61	11	0.35
1969	17	0.60		0.33
1970	14	0.58		0.33
1971	13	0.56	9	0.35
1972	15	0.52	8	0.28
1973	12	0.38	9	0.34
1974	11	0.46	9	0.37
1975	12	0.56	8	0.46

[a]This represents the total number of minor reference areas used in each continental survival estimate.
[b]Total proportion represents the estimated proportion of the continental mallard breeding population to which the mean survival estimates actually pertain.

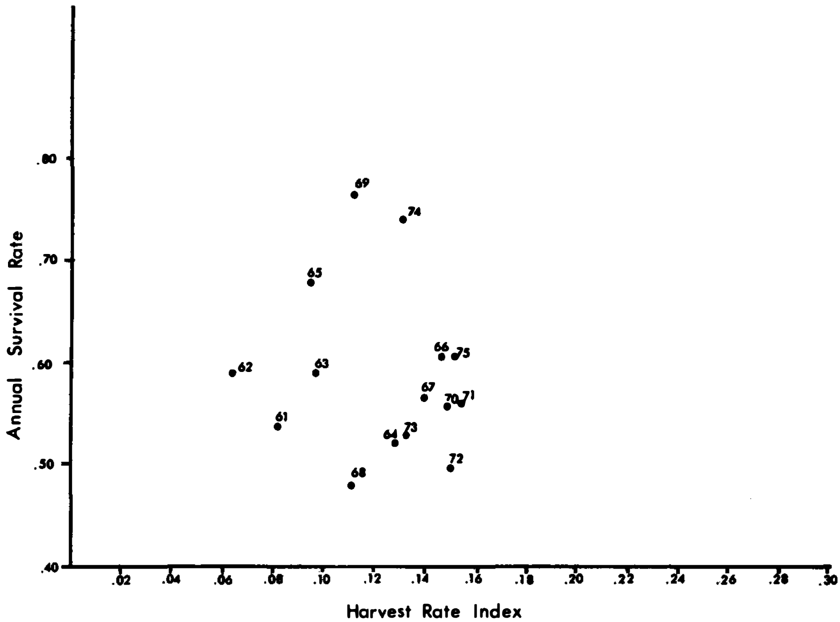

Figure 1. Relationship between survival rate and harvest rate index for adult male mallards.

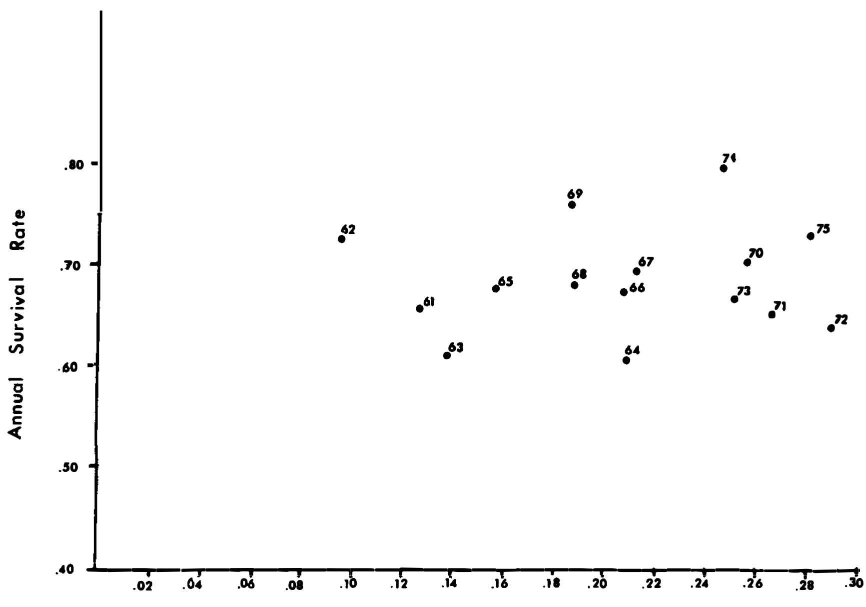

Figure 2. Relationship between survival rate and harvest rate index for adult female mallards.

particular, shows a wide range of values in the harvest rate index with no apparent relationship to survival rate. Linear correlation analysis showed no significant relationship between the two variables for either males ($r = 0.0947$, $r^2 = 0.0090$, $t_{13} = 0.3430$) or females ($r = -0.1366$, $r^2 = 0.0187$, $t_{13} = -0.4972$). We conclude that this analysis provides no evidence that survival rates decrease in response to increased harvest rates.

Summary and Conclusions

Various hunting regulations are used to control the legal harvest of ducks in the United States. Although it is difficult to evaluate effectiveness of specific regulations, the general type—liberal or restrictive—appears to have a marked effect on harvest.

Our examination of mallard banding and other population records showed no relationship between harvest and survival rates in the overall population. Although harvest rates have been higher in recent years, overall survival rates have not differed from those in years of restrictive regulations and lower rates of harvest. Survival rates of young and adult mallards vary from year to year, but hunting mortality does not seem to be the cause of such changes. These findings have important implications, not only in management of mallards but for other species of ducks as well. For example, in setting regulations during the last few years we have attempted to provide a somewhat greater and more stable level of hunting opportunity than has generally been the case in previous years when they varied greatly in degree of restrictiveness from year to year. There is no evidence, at this time, that this has had detrimental effects on the resource.

Our findings support the conclusions reached earlier by Anderson and Burnham (1976) who believed that hunting mortality largely is compensatory to natural causes of loss. We should point out, however, that although we benefitted from 5 years of additional data, we employed the same methods used in the previous study. Results of our analysis thus are subject to the same limitations. In particular, despite the large volume of data available for study, we are concerned about the inadequacy of information on key population segments. Hunting mortality may be impacting upon birds in some areas.

There clearly is a need to develop a better understanding of the relationship between hunting and natural mortality in mallards and other ducks. We believe it is essential to better understand the magnitude, causes, and timing of natural loss in ducks, and suggest that the importance of natural loss has not received adequate attention. Such information would be valuable for many reasons, including helping to identify priorities for habitat acquisition and preservation. It is also especially important to identify the "threshold" levels at which hunting increases total mortality. Until we gain such knowledge, regulations must continue to play an important role in the management of ducks.

Acknowledgements

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Can Ducks be Managed by Regulation in Canada?

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The hunting of ducks in Canada has been regulated for the past 30,000 years, from 28,000 BC to 1917 AD, since man first crossed the Bering land bridge. In that interval, God decided on the numbers of birds that would be available.

There was no need for man's intervention before the "discovery" of North America. The sparse human populations of the continent, with primitive technology, posed no threat to waterfowl. By 1890, 400 years after Columbus, there were perhaps 100 million humans in North America. Still, there was no apparent need for the intervention in God's affairs by man, despite the destruction of the prairies in the United States from Illinois to North Dakota or the invention of the U. S. Army Corps of Engineers, because the prairies of Canada were largely in pristine condition. There were still plenty of ducks and geese for all, until Canada too made a deliberate decision to settle its prairie regions.

It might well be argued that fall flights of ducks in pre-European days on both sides of the international boundary were about equal and in the order of about 100 million per country. In 1978 the continental fall flight of ducks was considerably less than half that historic estimate and 80 percent was generated in Canada. It could also probably be argued that 30 percent of Canada's waterfowl breeding habitat and 80 percent of that of the United States has been ploughed under, drained, overgrazed, polluted, or otherwise abused. In 1977 not fewer than 2,500,000 licenses were sold to hunt waterfowl in Canada and the U. S. The total hunting-associated kill from a continental fall flight of less than 100 million is in the vicinity of 27 million and natural mortality accounts for another 10 million. This might imply an overall mortality of about 40 to 50 percent of some species. Such generalities have plagued managers for years because included in fall flight estimates are species like oldsquaw, scoters, king eiders, which reproduce slowly and which because of distribution are only lightly gunned. These estimates of annual mortality are further confused by the signal lack of data from south of the Rio Grande. Finally we all can acknowledge the fact that some populations are more heavily exploited than others.

Since 1916, man has stepped in to regulate those things that are clearly beyond the scope of God, that is, the control of man.

The question posed to this panel is "Can ducks in Canada be managed by regulations?" A better statement would be "Can man be regulated to perpetuate duck hunting"—because in reality we regulate man not ducks. One of the great imponderables is, why do we have regulations? What is their intent and how effective are they? There are two basic premises to regulations expressed in the preamble to the U. S. Fish and Wildlife Act: (1) to prevent over-exploitation and (2) to distribute the kill amongst hunters in an equitable fashion. In the short term, regulations in Canada have not generally accomplished the second of these stated U. S. goals. The bulk of Canadian hunters kill fewer than 5 birds per year, but some shoot as many as 200. We have not legislated the number of days a man can go hunting in a 60-day effective season, nor have we legislated the ducks to distribute themselves equally throughout the country, nor have we tried. We cannot legislate equal opportunity of access to birds, the numbers of birds available, or the number of days when it is feasible for a man to take time off from regular employment to hunt ducks. We can legislate the conditions of hunting and place restrictions on the numbers of birds and the kinds of birds that can be taken on any given day, but that is to prevent over-exploitation, which is a stated Canadian objective and the second basic tenet of regulations. Traditionally, regulations have been set in Canada and on this continent to protect the mallard, black duck, wood duck, hooded merganser and canvasback. Bonus species have been the scaup, goldeneye, oldsquaws, scoters and eiders and teal. It seems to the cynics amongst us that the less we know about a species, or the more slowly it reproduces, the more likely it is to provide a bonus or extended season applicable to that species.

There is a widely held, but I believe mistaken, point of view that regulations set in Canada must necessarily mimic those in force in the United States. This is neither possible, nor desirable. In actual fact if one desires to protect late migrants from overexploitation, it is necessary that U. S. Regulations be supportive of those set earlier in Canada.

About August 15, populations of waterfowl in Canada are at a peak. If one draws an analogy to a petroleum fraction column with three types of crude oil subjected to heat, evaporation of the light distillates which include blue-winged and green-winged teal and pintail evaporate very quickly; by September 1, 90 percent of the fall flight of these three species have migrated south and are not available to Canadians. Indeed their harvest in Canada represents less than 6 percent of their Canadian production. The next group of species are the hard core, those of the greatest interest to Canadians and Americans alike. These include the large *Anas*, widgeon, gadwall, the diving ducks such as scaup, ring-necks, bufflehead, canvasback and redheads. Their withdrawal from Canada is more leisurely and Canadians harvest 13 percent of the fall flight of those species. Indeed because of the early retreat of less robust species, mallards plus blacks represent 52 percent of the Canadian kill compared with only 37 percent of the U. S. kill.

The final group, the "bunker C" of the ducks, consists of scoters, eiders, oldsquaw and goldeneye. They either don't leave our waters or are generally unavailable to or undesired by U. S. hunters.

Of a Canadian produced fall flight of 60 to 70 million ducks, Canadians are forced by climate and treaty to concentrate on species representing 30 million birds.

Canadian waterfowl managers envy their counterparts in the U. S. where salubrious climate and leisurely passage of Canadian bred waterfowl to their wintering grounds permits managers to exploit such options as an early teal season, a split season to get dabblers and divers or a late bonus season to obtain underharvested male mallards—a 60-day effective season. In Canada, effective seasons of 60 days are virtually unknown except in coastal regions and along the Great Lakes. Each year in most of Canada we play a sort of Russian roulette. Administratively, Canada is divided into 64 hunting zones, 54 of which are likely to be frozen out before November 1. For several years we have been attempting, unilaterally it seems to some, to protect mallards and canvasback breeding in S.W. Manitoba, opening our seasons late and watching the escapement of teal, gadwall, widgeon, even mallards.

In order to protect the large forms of *Anas* and *Aythya* we have set regulations making it difficult to hunt species representing 50 percent of the fall flight of Canadian raised dabblers.

We have recently completed a first draft of Canadian National Waterfowl Management Plan. Although preliminary in nature, it is now clear to Canada at least that we cannot much longer manage waterfowl by "looking after" the mallard, the black duck and the canvasback, and it is equally clear that Canadian and U. S. regulations *must* interface more closely.

As you will hear from Dr. Patterson, the rate (Canadian plus U. S.) of exploitation of many populations breeding in prairie Canada is increasing. Populations of mallards and pintail are being artificially held at high levels in prairie Canada, not to satisfy Canadian needs, but continental needs for we harvest only 7 percent of the total prairie fall flight. This is politically and economically an increasingly difficult goal to maintain. In order to preserve prairie nesting (grain belt) mallards, we have set conservative and on occasion, punitive bag limits and late season opening dates. The kill of mallards in Canada as a whole has stayed constant because of an eastward extension of the range into Ontario and Québec. But the portion of the kill of mallards from prairie Canada has been steadily decreasing since at least 1972.

In conclusion, waterfowl in Canada, except for a limited number of species or populations that do not migrate south of our political control, cannot be managed by Canadian regulations alone. We can regulate the take in Canada but not for the rest of the range of a species. For most early migrants we cannot take advantage of more than a small fraction of our production. For late migrants, including geese, *Anas* and diving ducks, we can regulate the sport kill over a fairly wide range, even reducing it to zero as in the case of Atlantic brant. Canadian regulation-setting philosophy is increasingly to maintain consistent bag limits and season dates where possible and let the laws of supply and demand operate, interfering only when the populations get in trouble. This is a reasonable procedure under Canadian climatic conditions. We believe that major reductions (50 percent) in the Canadian harvest of most populations would contribute at best an additional 50,000 to 150,000 birds per species to increase the number of breeding birds in the year following. This is patently a futile exercise unless those birds survive hunting seasons south of Canada. What I am saying, in essence, is that restrictive regulations in Canada designed to increase breeding populations of late migrants will largely be ineffective unless matched by other users of the resource.

To answer the question posed to the panel, yes, we have managed ducks in Canada by cooperative regulation but we are approaching a critical period in the exploitation rate of the late migrants which will require even closer integration between not only Canada and the United States, but Latin America as well. We must now give consideration to the minor species or they may disappear whilst we still have mallards.

Can Ducks be Managed by Regulation?

Experiences in Canada

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Introduction

I would suggest that the panel topic "Can ducks be managed by regulation?" is composed of two separate questions: (1) "Can the annual kill of ducks be affected by regulations?", and (2) "Can the size of the annual kill influence, or manage, duck population size?"

The first question is relatively straightforward. Restrictive hunting regulations in the Prairie Provinces in recent years have demonstrated that the Canadian waterfowl kill can be reduced by lower bag limits. The second question has traditionally been more complex. This complexity has been augmented by the concepts of compensatory mortality and threshold levels put forth by Anderson and Burnham (1976).

I intend to discuss the influence of sport harvest on a number of prairie-nesting duck species in a somewhat speculative manner. This approach will be based on broadly stated hypotheses and a generalized application of existing data. To proceed in this manner may be considered scientifically rash. However, I feel that we must work towards a predictive strategy for the multi-species exploitation of waterfowl. These efforts are essential if we are to avoid a supply and demand impasse in waterfowl management. I will be speaking primarily from the point-of-view of prairie Canada.

Methods

Data sources were primarily from annual surveys of (a) breeding populations conducted by the U. S. Fish and Wildlife Service (USFWS) and the Canadian Wildlife Service (CWS), and (b) sport hunting kill surveys in Canada by CWS (Cooch et al. 1978) and in the United States by USFWS (Greenwalt 1975).

Species harvest rate indexes used in this paper are simply the ratio of the total kill in the United States and the three Prairie Provinces, over the North American fall flight expressed as a percentage. North American fall flights were calculated by summing the breeding population, and the product of the breeding population and the adjusted immature to adult ratio.

The Requirement for an Exploitation Strategy

Breeding duck populations which inhabit the prairie-parkland region of North America exist in an extremely dynamic and unpredictable set of environments. Climatic cycles produce wide annual variations in the quantity and quality of wetland habitat. For example, the number of ponds estimated from the annual breeding-ground survey has varied for a high of 7.3 million to a low of 1.6 million in the period 1955–1978. Numbers of all prairie-nesting duck species fluctuate in response to this habitat availability, but not to the same extent. This is to be expected, as each duck species would evolve a somewhat unique set of reproductive and survival strategies in response to environmental conditions.

Superimposed on the natural variability in the quantity and quality of breeding habitats are the impacts of man's industrial, urban and agricultural developments on breeding, migration and wintering habitats. All information indicates that environments used by prairie-nesting waterfowl are being lost or degraded at a substantial rate throughout North America. There is widespread concern that the reproductive potential of prairie-nesting ducks has declined over the past three decades in response to habitat degradation. Simulation modelling exercises such as that conducted on the mallard by Hochbaum and Caswell (1978) indicate that only small population gains could be expected by harvest reductions, but substantial increases in breeding populations could be expected from management programs that improved recruitment.

Conversely, Trauger and Stoudt (1978) presented the case that reproductive performance of prairie-parkland dabbling ducks has not declined over the past several decades. They suggested that declines in dabbling duck populations were caused by factors affecting the densities of breeding adults. While habitat quality and quantity have declined in the prairie-parkland area, it has not progressed to the extent where it could be responsible for the present state of waterfowl populations. Trauger and Stoudt concluded that these populations are being overharvested in North America.

In this complex and dynamic situation, the waterfowl biologist is charged with managing the exploitation of a multi-species assemblage of ducks in a manner that will ensure both the long-term preservation of stocks and optimum levels of sport harvest. In comparison to other natural resource management disciplines, I would submit that we do not have a comprehensive theory of exploitation as a basis for this task. The craft of managing duck populations through harvest regulation has traditionally been based on empirical considerations of population status and harvest, with the majority of effort being directed to the mallard (*Anas platyrhynchos*). While this approach may have worked in the past, it is my opinion that conditions affecting waterfowl are changing to the point where we must endeavour to develop a multi-species exploitation strategy that is based on sound ecological principles.

A notable exception to this generalization is the landmark paper by Anderson and Burnham (1976). To quickly summarize their findings, Anderson and Burnham concluded that up to an unidentified threshold level, hunting and nonhunting mortality were largely compensatory forms of mortality for the mallard. To address the topic of this panel, the Anderson and Burnham hypothesis would suggest that if hunting mortality is below the threshold point, a restriction in harvest would not produce more ducks in the population. In other words, ducks cannot be managed (or stockpiled) by regulations if hunting mortality is below the threshold point.

As the most numerous and widely distributed duck species in North America, the mallard is generally considered to be a very opportunistic species that can sustain a relatively high rate of hunting mortality. Conversely, a long-lived species, such as the canvasback, would be expected to have a lower threshold point. Anderson and Burnham (1976) address this point quite clearly. They note that species' threshold point must be less than the natural mortality rate in the absence of hunting. Species having low natural mortality rates, such as the canvasback (*Aythya valisineria*), would have less capability to compensate for an additional form of mortality such as hunting. North American regulations reflect our recognition that the mallard and canvasback are at opposite ends of the threshold spectrum.

The Anderson and Burnham hypothesis has had a considerable impact on the philosphy of waterfowl hunting in North America. I am concerned that the mallard will be used as a yardstick with which the numerical kill of other species is evaluated. It is imperative then, to try to determine the threshold points, or ranges, not only for the mallard, but for all duck species that we harvest. Unfortunately, there appears to be no quantitative method of predicting threshold values. If representative survival estimates were available for all duck species, we could at least idenfity the species-specific level of mortality, below which the threshold points would be. However, considering that almost 700,000 mallard bandings over a period of a decade, were used as a data base by Anderson and Burnham, it is highly unlikely that we will develop an equivalent analysis for all species. We have neither the time, nor the resources, to acquire these data.

In spite of this lack of empirical data, I believe we can still make some headway. Perhaps we are pressing too strongly for very precise, but limited data, and are losing sight of the forest for the trees. There is a wealth of conceptual information in the ecological literature that may provide direction. I do not pretend to think that ecological theory will provide us with exact management answers. However, I believe that the marriage of the existing empirical data base on duck populations with modern ecological concepts can provide us with a framework for a more specific hypothesis that we can address in an experimental manner. Later in this Conference, Tom Nudds of the University of Western Ontario, will be presenting a thought-provoking paper on the need for ecological theory in wildlife conservation and management.

The Application of Ecological Theory

We have two long-term, extensive data sets relative to the major duck species that breed in the prairie-parkland region of Canada: annual estimates of breeding population size, and annual estimates of hunting mortality both in Canada and the United States. Can this information be used to work towards a multi-species exploitation strategy? There are numerous contributions in the ecological literature that deal with the evolution of life history strategies in various organisms. One concept which holds promise for understanding life history strategies of duck populations is that of r and K selection (MacArthur and Wilson 1967). r refers to the intrinsic rate of increase of a species and K is the environmental carrying capacity for this species. In general terms, r strategists are thought to have evolved in seasonal, or unpredictable environments. They exhibit life history characteristics such as a high rate of natural increase, early reproduction, large litter or clutch size and short lifespan. K strategists are thought to have evolved in more stable environments, and exhibit life history characteristics such as low rates of natural increase, delayed reproduction, small litter or clutch size and long lifespan.

This account of r-K theory is relatively simplistic in view of the more detailed considerations of Nichols et al. (1976), Ricklefs (1977) and most recently Whittaker and Goodman (1979).

r-K theory is attractive for our purpose in that the major biological phenomena being considered is the proportion of an organism's total resources which are allocated to reproductive activities. Nichols et al. (1976) note that the above mentioned life history characteristics are correlates of r-K selection. If we could apply this concept to duck species, existing information on the breeding component of their life history may give us direction and understanding of the mortality component where data is lacking.

Within the waterfowl world, the mallard would seem to be a typical r strategist. It is catholic in its habitat requirements, being found extensively across North America in a wide variety of aquatic environments. It has also demonstrated considerable reproductive potential by rapidly recovering from periods of harsh environmental conditions. The mallard has relatively high mortality rates and can sustain considerable harvest pressure.

Conversely, the canvasback exhibits characteristics of a K strategist. Breeding habitat requirements are much more specialized than that of the mallard. It is typically found on deeper, more permanent, wetlands, offering overwater nesting cover (Sugden 1978). The canvasback's selection of breeding habitats ensures a more stable environment through wet and dry climatic cycles. Canvasbacks are known to be delayed breeders, whereby yearlings do not have the same probability of successfully nesting as dabbling ducks (Bellrose 1976). Delayed reproduction in diving ducks would be expected to lower the rate of natural increase. As a longer lived species, the canvasback should have a lower natural mortality rate than that of the mallard and as a result have less capability to compensate for an additional form of mortality such as hunting.

Two simple hypotheses were proposed to assign the relative position of 10 major prairie-nesting duck species along an r-K continuum. In the first, it was assumed that r strategists would react quickly to occupy available breeding habitat. This hypothesis was tested by plotting May breeding populations in the prairie-parkland region of Canada against May pond numbers in the same area for the period 1955–1978. The second hypothesis assumed that K strategists would demonstrate some form of self population regulation. Populations would be expected to equilibrate in relation to the carrying capacity. This hypothesis was tested by plotting the May breeding population (N) in year t against the difference between N_t and N_{t+1}. If a population was self regulated, a high population in any one year would be followed by a population decrease in the following year, and conversely, a low population would be followed by an increase.

Table 1 gives a summary of these analyses. In the first test, the linear regression of May breeding population against May pond numbers was significant at the 1-percent level for blue-winged teal (*Anas discors*), pintail (*Anas acuta acuta*) and shoveler (*Anas clypeata*). Mallard, wigeon (*Anas americana*) and redhead (*Aytha americana*) were significant at the 5-percent level. Blue-winged teal, pintail and shoveler can be considered as strong r strategists, while the Mallard, Wigeon and Redhead exhibit less pronounced r attributes. In the second test, for K strategy, all species with the exception of mallard and blue-winged teal showed negative linear regressions that were significant at the 5-percent level or above.

Table 1. Relative grouping of 10 major duck species in an *r*-*K* continuum.

	Mallard	Blue-winged teal	Pintail	Shoveler	Wigeon	Gadwall	Green-winged teal	Redhead	Canvasback	Scaup
r-STRATEGY										
N_t vs P_t (*P*<0.01) *(*P*<0.05)	No*	Yes	Yes	Yes	No*	No	No	No*	No	No
K-STRATEGY										
$N_{t+1} - N_t$ vs N_t (*P*<0.05)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

← *r*-DABBLERS —— X —— *K*-DABBLERS —— X —— *K*-DIVERS →

On the basis of these two simple tests for *r* and *K* attributes I would suggest that mallard, blue-winged teal, pintail and shoveler could be considered *r* strategists. The remaining dabbler species, wigeon, gadwall (*Anas strepera*), and green-winged teal (*Anas crecca carolinensis*) could be considered as *K* strategists. I have grouped the diving ducks, redhead, canvasback and scaup into a separate *k* category on the basis of delayed breeding, which would lower the rate of natural increase in comparison to the dabbling ducks.

Considering the a priori assumption that the mallard is a very opportunistic species, it is surprising that the mallard was not as strongly related to pond numbers as the other *r* dabblers. If an *r* species was to exhibit this positive relationship with habitat, we would be assuming that other factors were not exerting a major influence on the population. Figure 1 indicates that this may not be the case for mallards. In the upper graph, breeding mallard populations in the prairie-parkland area of Canada are plotted against year, in the period 1970–1978, which follows the Anderson and Burnham analyses. Although the breeding population varies in a nonlinear manner, the general rate of decline during this period is described by a negative linear regression at the 5-percent level of significance. The lower graph plots mallard harvest rate index for the period 1969 to 1977. This plot is described by a positive linear regression at the 1-percent level of significance.

I am not implying that these data prove that the mallard harvest has exceeded the threshold point. I would suggest, however, that current harvest measures could be impairing habitat utilization by mallards in the prairie-parkland region. This suggestion is consistent with the conclusions of Trauger and Stoudt (1978).

Having proposed that prarie-nesting ducks can be separated into three groups on an *r-K* continuum, is it possible to identify ranges where the group threshold levels might be? The *r-K* concept indicates that mortality rates should be highest in the *r*-dabblers, intermediate in the *K*-dabblers and lowest in the *K*-divers, but beyond this point ecological theory does not help.

Anderson and Burnham (1976) indicated that we may have exceeded the threshold point for the mallard on a continental basis in 1964 and 1970. As noted previously in Figure 1, mallard harvest rates have increased since 1970, coincident with declining breeding populations in the prairie-parkland region. I would suggest that we are at, or near, the threshold level for mallards now. The threshold level for *r*-dabblers then should be in the area of 40 percent, in terms of the harvest rate index used here.

In Figure 2, changes in May breeding populations in the prairie-parkland area of Canada and harvest rate indexes are shown for redhead and canvasback, examples of *K*-divers, and wigeon and green-winged teal, examples of *K*-dabblers.

The abrupt drop in the harvest rate index for canvasback and redhead in the early 1970s was in response to severe restrictions in the U. S. harvest brought about by area closures. Breeding populations of both species increased substantially after this restriction. Since that time the harvest rates have increased again and breeding populations have declined. From this information I would suggest that the threshold level for *K*-diving ducks is likely in the area of a 10 percent harvest rate index.

Harvest rate indexes for the wigeon and the green-winged teal have risen sharply in recent years, with a coincident decline in prairie-parkland breeding populations. Boyd et al. (1978) identified the fact that sport hunting in North

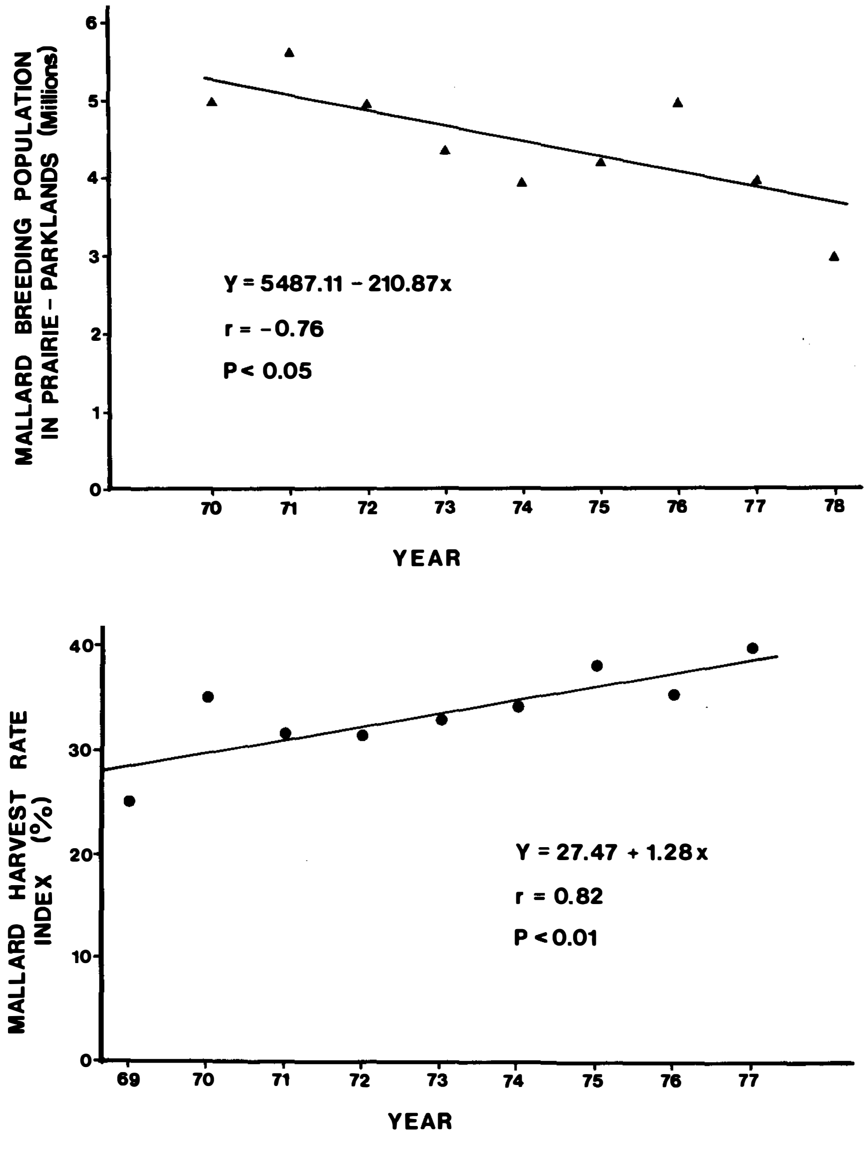

Figure 1. Trends in Mallard breeding populations in the prairie-parkland region of Canada, 1970–1978 (above) and Mallard harvest rate index, 1969–1977 (below).

America was taking a greater percentage of the fall flight of both wigeon and gadwall. He identified a need to focus research on one or both of these species in an attempt to establish where the threshold lies.

This analysis does not predict the threshold value for *K*-dabblers, however, it does suggest that the range should be intermediate between 10 percent and 40

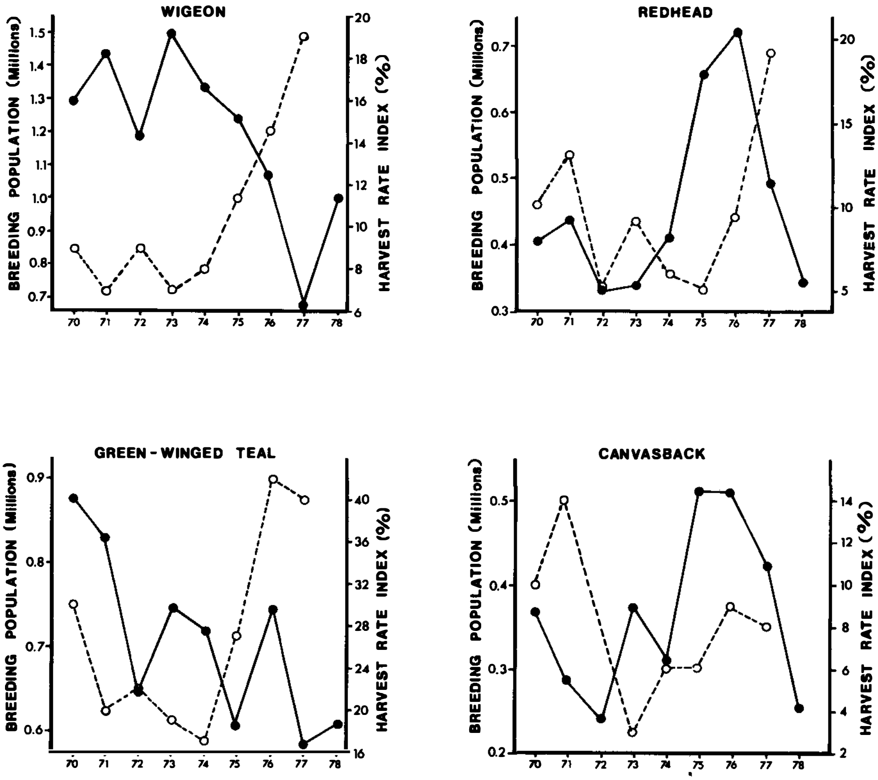

Figure 2. Trends in May breeding population in the prairie-parkland region of Canada, 1970–1978 (solid line) and harvest rate index, 1970–1977 (dashed line), for wigeon, green-winged teal, redhead and canvasback.

percent. We should not expect these species to sustain the same harvest rates as mallards.

Harvest rate indexes for the period 1970-1977 are shown in Figure 3 for each of the 10 duck species. Of the *r*-dabblers, only the mallard is being exploited at a substantial rate. Pintail, blue-winged teal and shoveler are harvested to a much lesser degree by Canadian and American hunters. In the intermediate *K*-dabbler group both the gadwall and green-winged teal have substantial harvest rates. In fact, green-winged teal harvest rates have on occasion exceeded those of the mallard.

The scaup (*Ayatha affinis* and *Ayatha marila mariloides*) is subject to the smallest relative harvest of the 10 species even though the numerical kill is higher than that of the redhead and canvasback. Some people have asked why the canvasback and redhead have not responded to present restrictive hunting regulations. As shown in Figure 3, even a very small numerical increase in the annual kill could have a large relative impact on the population by increasing the harvest rates substantially.

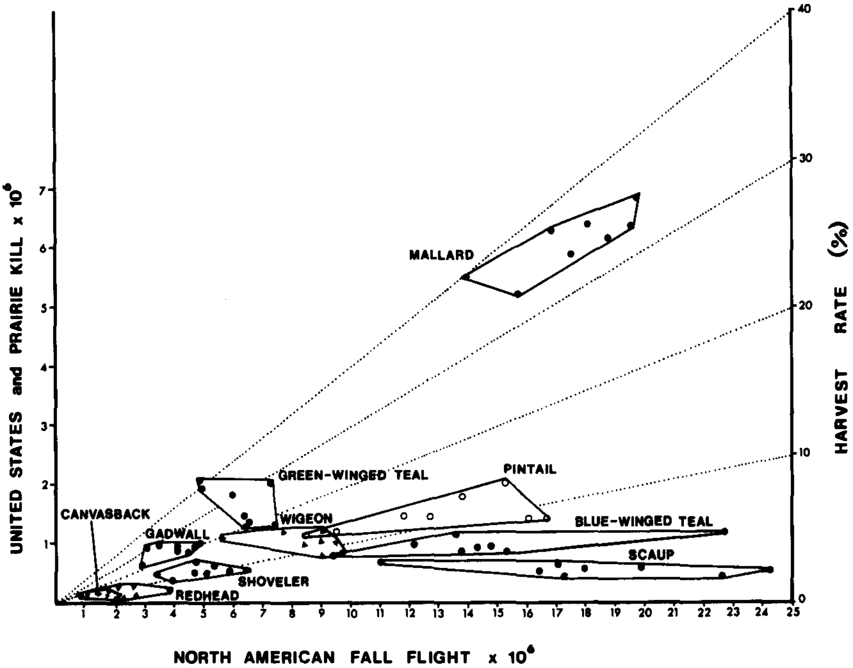

Figure 3. Harvest rate indexes for 10 duck species during the period 1970–1977. Polygraphs encompass calculated indexes for the 8-year period.

Conclusion

In conclusion, I would like to make three main points. First, it would seem that ecological concepts, such as *r-K* theory, have promise in contributing to the development of a multi-species exploitation strategy for ducks. The analyses in this presentation are quite superficial, however, the Canadian Wildlife Service will be continuing this work in a more detailed way.

Second, harvest pressures on a number of the so-called minor species are not insignificant. To evaluate the numerical kill of various species of ducks against that of the mallard is wrong. The proportion of the fall flight that is harvested may be substantial for these species, and be related to lower threshold levels. In the case of the mallard, the annual kill could vary in the order of a million, and depending on the size of the fall flight, not change the harvest rate. However, with a species such as the canvasback, even a minor numerical increase in the kill could have a marked impact on harvest rates.

The final point I wish to make is that waterfowl management in North America has tended to focus primarily on the mallard. We should endeavour to develop a more balanced waterfowl management and research program, which includes experimental testing of hypotheses with the most appropriate species.

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Wildlife and Fisheries Research Needs

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Opening Remarks

Ronald F. Labisky

Welcome to this special session on fish and wildlife research. The series of invited papers in this session, all multi-authored by design, will be presented in a sequential pattern. The session will open with a brief assessment of problems impacting the conduct of research. The current state of the art will then be reviewed, after which future research needs and priorities will be identified. The next group of papers will evaluate the roles and responsibilities of federal agencies, state agencies, and academic institutions in conducting fish and wildlife research. And, finally, we shall explore pathways for enhancing our collective research efforts to preserve, conserve, and manage the fish and wildlife resources of this nation. Obviously, this will lead us to a discussion of increased funding for fish and wildlife research.

Today's program was spawned or fledged, depending on your scientific pursuasion, by the National Fish and Wildlife Resources Research Council. This Council is comprised of an ad hoc body of professionals whose purpose has been, and is, to promote increased funding for fish and wildlife research at academic institutions. To achieve this goal, the Council has developed a three-step strategy. The first step is intended to document national needs in fish and wildlife programming, and to identify those needs, as well as the Council's initiative, to the fish and wildlife community. Today, at this session, that step will be implemented. The second step will entail preparation of a "white paper." This working document will be based in part on the papers presented here today. The purpose of the white paper will be to provide the foundation from which to launch the thrust for legislative support of the funding package. The third step will be to promote passage of federal legislation that will provide for sustained funding of fish and wildlife research programs at academic institutions.

The task undertaken is difficult; it is also significant and necessary. The key to successfully meeting this challenge, and those challenges to come in the decades ahead, will depend on the strength and unity that we can generate as a profession. The old adage—"united we stand, divided we fall"—still applies. Translated into today's jargon, it means that we need professional ''clout'' if we are to move progressively forward in the discharge of our responsibilities. To this end, your commitment and support, individually and collectively, is paramount.

I would be remiss if I did not identify the members of the Council's Program Steering Committee who planned and developed this session. The Committee included Ernest D. Ables, University of Idaho; George V. Burger, Max McGraw Wildlife Foundation; Alexander T. Cringan, Colorado State University; Gerald H. Cross, Virginia Polytechnic Institute and State University; William R. Edwards, Illinois State Natural History Survey; W. Harry Everhart, Cornell University; Willard D. Klimstra, Southern Illinois University; Richard L. Noble, Texas A and M University; Tony J. Peterle, Ohio State University; Donald R. Progulske, University of Massachusetts; Dixie R. Smith, USDA-Forest Service; Stephen C. Smith, University of Wisconsin; Rollin D. Sparrowe, USDI-Fish and Wildlife Service; Richard A. Tubb, Oregon State University; William G. Youatt, Michigan Department of Natural Resources; Laurence R. Jahn, Wildlife Management Institute [*ex officio*], and myself as chairman.

Another group of people deserves special recognition also. That group consists of the authors of the invited papers. It was their enthusiasm, commitment, and tenacity that allowed this session to become a reality.

Assessment of Problems in Fish and Wildlife Research

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Fish and wildlife research at U.S. universities has yielded many importatnt accomplishments. Yet, in our judgement, its full potential remains unfulfilled. A higher order of achievement could be realized with a more adequate and secure funding base. A major purpose of this session is to define that potential, to suggest strategies for its accomplishment, and to start laying the basis for securing the requisite funds. Your participation in reaching these goals will be most important.

An historical critique of fish and wildlife research is not appropriate at this time; subsequent papers analyze problems for future research. We shall focus on the forces shaping public policy today, and on the factors which should be considered in organizing for the future. We must take the current phase of fiscal parsimony into account, but it is not our fundamental concern; we do not agree with those who say that today's retrenchment in the availability of public funds is an argument for a do-nothing policy. Time horizons for taking certain actions have short-term objectives which will be affected by austerity and anti-inflation policies. But our prime concern should be with longer-term goals, direction setting, and organizing interested parties.

A few points should preface our discussion of the main issues. First, federal responsibility for many aspects of fish and wildlife has been increasing during the past several decades. Execution of this responsibility should be placed within a management–policy context and should be dependent upon a research-based information system. New federal legislation is needed to clarify the responsibility for developing this research base, to define the university's role in setting priorities and conducting research, and to provide funds.

Second, we shall propose federal augmentation to funding university research as a means of dealing with selected high-priority national problems. This proposal, however, does not conflict with the established program of Cooperative Wildlife and Fisheries Research Units. These units are doing important work, and should be complemented by additional, independent university effort.

Third, no great expansion of new programs is contemplated, only a rounding out and strengthening of present research programs. To bring this about requires an increase in assured base funding. Stability will insure development of badly needed longterm ecosystem studies. Also, mechanisms for university scientists to cooperate across state lines and with neighboring countries must be established in order to deal with the variety of ecosystem problems which transect political borders.

The achievement of an increase in base funding for universities will be accomplished not by wishing but by hard work, leadership, cooperation, and maintenance of a scholarly scientific approach. As opposed to other opportunities for expending federal research dollars, university-based fish and wildlife research will have to rank higher on the public priority scale than it does today. To change this ranking, several things must come about:

1. Fish and wildlife will have to be valued as important by the public, and the public will have to perceive that research is essential to that value.
2. The University should clearly establish itself as a locus for ecological and socio-economic research for both game and nongame species.
3. Scientists working at universities must organize and develop strategies for increased research funding as well as focusing upon disciplinary advancement.

A Public Perception of Value

With respect to the public perception of value, the flowering of the "environmental era" has given fish and wildlife a tremendous national exposure, and has dramatically broadened public awareness. As a part of the etiology of our disciplinary area, strong national interest groups with broad bases of support have arisen, and specific types of information have become critical for activities such as the preparation of environmental impact statements. All of these factors have produced a public perception of game and nongame fish and wildlife issues which is both different and greater today than 40 years ago.

Scientists are frequently uncomfortable with the showmanship and other public relations efforts required in such highly visible activities as television and politics. Yet, scientists can and must build upon the public awareness of and value perceptions for fish and wildlife created by these activities if base funding for university research is to be expanded. Many professions do not have the opportunity to work within the context of a complementary and supportive public awareness; we should take advantage of this opportunity to build an understanding of the need for research.

Strong, competently managed interest groups, reflecting the status of public values, exist at the national level. Many of these groups have a local organizational base. The development of the North American Wildlife and Natural Resources Conference, on an annual basis, is only one evidence of this strength. We should capitalize on the strong national identity of these groups, and explore opportunities for organizing national coalitions for support.

Fish and wildlife researchers have complained that they do not have strong economic bases comparable to those of commercial agriculture or forestry. True, the fields are quite different. But fish and wildlife is not without its own unique strengths—in fact, others are envious of the potential. The current public perception of fish and wildlife resources and the existence of viable conservation organizations are major assets.

The University, a Locus for Research

To build the financial base for research, proposed programs must be socially and ecologically meaningful. The public will need to identify with these proposals. Further, these programs will have to pass the hurdles of the Office of Management and Budget. One test will be the application of a simple benefit–cost analysis. We must be prepared for this eventuality, but not be trapped in a web of unreality. Benefit–cost analyses are subject to all manner of "shading" as assumptions are fitted together to yield results. It is useful and, in fact, essential to think through the benefits and costs of a proposed line of research, but this procedure is quite different from putting presumed market values on every research proposal. University research should, after all, deal with problems whose answers are unknown.

The important niche of university scientists in achieving significant research results must be more clearly articulated for both game and nongame species. The federal laboratory, state research group, private foundation, and university each has unique qualifications and environments to perform certain types of research. The potential for complementarity is not being fully exploited, in part because of inadequate base funding for universities.

At times, fish and wildlife activities conflict with each other. The actions of one user group are, or are perceived to be in competition with other user groups for the same base resource. In such situations of conflict, the university, without management responsibility, often provides the best environment for studying alternative solutions.

The mechanisms or administrative procedures providing federal investment in university research are important since they affect research output through many avenues, including problem selection and restraints on expenditures. A significant debate is currently in process over formula or grant funding or their appropriate combination. We support some combination, but the fundamental thrust to increase base funding can only come through a strong formula program.

The argument is made that universities can and should subsist on grant and contract research. True, very important programs are moving forward on this basis. Also, some scientists voice the opinion that only the National Science Foundation can determine what is socially and ecologically beneficial. The Foundation has been *most* supportive, and is *exceedingly* important, but few would argue that Foundation criteria set the only route to significant research findings.

By no means are we stating that universities should give up grants and contracts. But dependence of university research on "soft" money shifts the priority-setting prerogative. As a result, a most significant group of problems remains unaddressed, for one reason because pressures for problem formulation within the university context differ from those within governmental agencies with management, regulatory, or "pure" science responsibilities.

The campus has a unique capability for setting research priorities: for example, freedom from management "firefighting," diverse disciplinary interest, and independence from management policy. It is in the national interest to enhance this capability, and to place a portion of the "federal" research agenda within the context of campuses. Federal agencies such as the Fish and Wildlife Service, the National Science Foundation, the Forest Service, and the Environmental Protection Agency clearly have research agenda set within the push and pull of the federal agency milieu. Strengthening the university point of decision making would be in keeping with our pluralistic government and with our national interest.

Ecosystem problems are many-faceted, demanding technical input from many points of view. Universities generally provide a setting for developing intellectual interest easily and quickly from a variety of disciplinary areas, and for tapping the biological and physical sciences as well as integrating with the social sciences. The ability to work on system problems on a colleagueal research basis is a most important element of the university environment. This horizontal openness should be nurtured in developing research thrusts. Colleagueal cooperation—quite different from assembling a research team by administrative direction—can be enhanced by strengthening the university locus of research.

The Importance of Organization

Finally, university fish and wildlife researchers are independent souls! For this, we are thankful; it is a trait which should not be lost. Yet, collective action is essential for achieving national funding goals. Professional representatives in Washington, D.C. have been exceedingly effective in putting together coalitions to achieve desired ends. We should learn from that model.

Frankly, the lack of organization among university scientists is amazing, especially since cooperative fish and wildlife programs involving universities have been in existence for over 40 years. Issues certainly have arisen about which it would have been important to raise a collective voice.

At the state level, establishment of a system for planning and communication among university, state, and federal fish and wildlife personnel frequently is nonexistent. These professionals meet successfully to deal with ad hoc issues, and at professional societies, but regular planning, communications meetings to inform, to avoid duplications, and possibly to coordinate programmatic interests, have been too few. Meetings for meeting's sake are to be abhorred, but we suggest a critical assessment of this issue. The Fish and Wildlife Service, in suggesting the development of state memoranda of understanding with State Cooperative Extension, may provide a spur for some states to think through these problems.

University fish and wildlife scientists should come to grips with the question of organizing to achieve their individual as well as their collective goals. This step is essential for raising the field's priority rank among federal funding alternatives and thus providing for a more stable funding system.

If, over the next decade, the university fish and wildlife community wants to develop a more stable funding base for research, public perception must be focused on the need and returns, a constituency must be developed, the university as a locus for research must be clearly defined, and an organizational net must be put together. This is no small task. It can be done, and it should be done.

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Status of Current Research in Wildlife

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Research is defined in *Webster's 3rd New International Dictionary* as "a studious inquiry or examination; *esp* critical and exhaustive investigation or experimentation having for its aim the discovery of new facts and their correct interpretation, the revision of accepted conclusions, theories, or laws in the light of newly discovered facts, or the practical applications of such new or revised conclusions, theories, or laws."

Wildlife biologists and many other scientists commonly speak of "basic" and "applied" research, without actually distinguishing between these imprecise terms. The National Science Board (NSB) (1977) distinguished these two kinds of research:

1. *Basic research:* "Research which has the purpose of acquiring scientific knowledge of natural phenomena, where the *primary* aim is fuller understanding of the subject of study, rather than specific application of the resulting knowledge."
2. *Applied research:* "Research which may have a similar purpose, but the prime aim is the potential application of the acquired knowledge."

Basic and applied research are two phases of a continuum extending from problem recognition to application. In entirety, this continuum exhibits five phases—problem recognition, basic research, applied research, development, and management.

The development phase is usually compressed or eliminated in the wildlife sciences. The successful transfer of the results of research to application in management is critical to scientific wildlife management.

An example of this continuum is the principle of trophic ecology, discovered as a result of Lindeman's (1942) basic research, and subjected to applied research during the International Biological Program (IBP) of the late 1960s and early 1970s. This principle is now applied by some wildlife managers.

Wildlife science is complex. Therefore, much of the research should be multidisciplinary, drawing upon biological sciences, including ecology and physiology; such physical sciences as biometry, organic chemistry, and electronics; social sciences, including economics and psychology; and such applied disciplines as agronomy, forestry, and range science. Some fundamental problems, capable of solution by individuals working within their own discipline, have been solved. These results helped identify the broader problems studied under the IBP, RANN (Research on Applied National Needs) and similar programs. Team research, such as conducted by animal ecologists and biometricians on population dynamics (Brownie et al. 1978) or wildlife biologists and organic chemists on pesticide–wildlife relations (e.g., Blus et al. 1975) is gradually replacing individual effort. Team complexity is increasing, and skills become more specialized.

Joint authorship in wildlife literature provides a crude index to multidisciplinarity. In 1968, there was an average of 1.8 authors for the 88 papers and 41 shorter articles published in the *Journal of Wildlife Management;* in 1978, the average was 2.2 authors for 72 papers and 75 articles.

Global mechanisms of information exchange have been developed by the international wildlife scientist community. Organizations such as the International Congress of Game Biologists afford opportunities for international exchange of research results. *Wildlife Review* indexes publications from more than 1,000 non-North American sources. Between 25 and 33 percent of 7,261 papers indexed in 1978 dealt with areas outside North America.

The NSB (1977) measured the nation's contribution to science against that of other nations by a number of indicators, including the nation's share of world publications by field of science. These indicators are not available for wildlife science, as the discipline was not recognized as a subfield by the National Science Board. The U.S. share of publications in biology for 1975 was 44 percent, and 48 percent of citations found in foreign publications were to U.S. sources. On the basis of current contents of *Wildlife Review,* we believe that comparable indices for publications in wildlife science would be higher. We suspect that well over half of the world's wildlife publications are by U.S. and Canadian authors.

It is likely that North American wildlife managers are the principal beneficiaries of worldwide research efforts in wildlife. Information published in English is readily exchanged among nations, especially between Canada and the U.S. Information published in other languages is less readily available to North American wildlife scientists.

In short, research in wildlife has these attributes: (1) it is difficult to discriminate between basic and applied research, as they are ill-defined portions of a single continuum; (2) it is increasingly multidisciplinary in structure; and (3) wildlife scientists in Canada and the U.S. are major contributors to, and beneficiaries of global research in wildlife.

National Resources for Research in Wildlife

In this section, we will identify the performers and funding sources of basic and applied research in wildlife, assess the funding in current and constant dollars, estimate the scientific manpower, and assess relative amounts of short-term and long-term research.

The National Science Board (1977) recognized four major sectors in the U.S. which perform research: private industry, federal laboratories, universities and colleges (and the federally funded research and development institutions which they administer), and other nonprofit institutions. State agencies are an additional major sector performing research in wildlife.

The important distinction between basic and applied research concerns the primary aim of the research. If the aim is fuller understanding, the research is basic; if application, the research is applied.

Charles V. Kidd, Executive Secretary of the Association of American Universities (in Smith and Karlesky 1977) wrote: "Universities provide a unique environment for research . . .The characteristics of that environment account for the fact that the center of gravity for basic research is in universities." We believe that universities ought to do basic research in wildlife, as in other sciences. Federal agencies should perform basic and applied research, as directed by their missions. Other nonprofit organizations ought to engage in both kinds of research. State agencies should conduct mostly applied, but also some basic research. Industry would be expected to engage almost exclusively in applied research.

Actual performance of basic and applied research by sectors differs from what would be expected. Much excellent applied research in wildlife has been done by universities (Weller et al. 1979). State-employed scientists often perform high-quality basic research; the study of mule deer anatomy and physiology by Anderson et al. (1974) is a case in point.

Universities are increasingly conducting applied research, as the result of accepting more short-term contracts for targeted research from government agencies. This change has been essential for universities to keep their research establishments financed. Grants for longer-term basic research have become more difficult to obtain.

As this point, we will drop any distinctions between basic and applied research, and speak instead of wildlife research in general.

The aggregate national investment in wildlife research is difficult to estimate. The NSB (1977) provided data on federal research obligations in "natural resources," which included wildlife. Minerals, water, land, recreation, and multi-resources also were included. Total obligations increased from $201 millions in 1969 to $504 millions in 1976 (constant 1972 dollars increased from $232 millions in 1969 to $377 millions in 1976). Fishery and wildlife research constituted only part of the recreation sub-function within "natural resources."

Loveless et al. (1979) suggested total expenditures of $74 millions on wildlife, fishery, and forest environment research by the U.S. Fish and Wildlife Service, National Park Service, and U.S. Forest Service in 1978. If the amount spent on fishery research is subtracted, and funding by the National Science Foundation, the health science agencies, and other federal sources not dealt with by Loveless et al. (1979) is added, it seems likely that total federal obligations for wildlife research are $30–40 millions annually.

It is still more difficult to estimate expenditures on wildlife research by other sectors. Each of the 50 state wildlife agencies does some wildlife research. Arner reported mean current annual expenditures on wildlife research of $200,000 per state for 10 southeastern states. We think it likely that state funding of wildlife research amounts to $10–15 millions per year.

Wildlife research expenditures by the university sector are especially hard to estimate. The Wildlife Society in November 1978 listed 85 U.S. campuses which indicated having special curricula related to wildlife conservation and management. Blaskiewicz and Lane (1978) listed graduate faculty with wildlife research interests at 72 U.S. universities. The National Wildlife Federation enumerated 148 U.S. universities in its *1979 Conservation Directory*. Arner reported mean current annual expenditures on wildlife research by universities of $245,000 per state for seven southeastern states. We think it likely that universities disburse $15–20 millions on wildlife research annually. Most of this is federal and state money, previously considered. Universities funded only 11 percent of the nation's basic scientific research in 1976 (National Science Board 1977). Further, grants from citizens' organizations such as the National Wildlife Federation, and from foundations, are often significant in funding wildlife research at universities.

Additional U.S. wildlife research performers include such citizens' organizations as the National Audubon Society, private foundations such as the North American Wildlife Foundation, Rachelwood Foundation, Welder Wildlife Foundation, and Max McGraw Wildlife Foundation, and corporations such as Weyerhauser. However, federal and state agencies and universities carry out most of the wildlife research.

Scientific manpower engaged in wildlife research cannot be estimated accurately. The Wildlife Society's U.S. members include about 5,000 practicing wildlife biologists. It seems probable that an equivalent of 12 to 25 percent of these, or 625–1250 scientists, would be working in wildlife research. Additional scientists who do not belong to The Wildlife Society are engaged in wildlife research. Blaskiewicz and Lane (1978) listed 418 wildlife professors at 72 U.S. universities who were active in supervising graduate research. (There were 43,754 biological scientists and 14,277 agricultural scientists at the doctoral level in 1975 [National Science Board 1977].)

Most U.S. wildlife research funds are for short-term (less than 5 years), rather than long-term (more than 5 years) research. We shall examine this question from the viewpoint of those who perform research.

Federal agencies are able to assign some wildlife scientists to long-term projects. Henny's (1972) monograph on avian populations in the pesticides era, the contribution to statistical analysis of banding data by Brownie et al (1978), and Thomas and associates' (1979) contributions to the understanding of habitat function are examples of the payoffs resulting from long-term research in federal laboratories. However, federally employed research scientists are increasingly required to invest more research effort into targeted short-term projects.

Some state agencies continue to do excellent long-term research, despite extreme and increasing pressures on state administrators to produce immediate answers to urgent problems. For example, researchers from the Wisconsin Department of Natural Resources have won two awards from The Wildlife Society for monographs on terrestrial wildlife within the past 5 years (Dumke and Pils 1973, Gates and Hale 1975).

University-employed researchers have few opportunities to develop adequately funded long-range research programs. Much available federal and state funding is for specifically targeted projects. Even some of the funding mechanisms designed for scientists in universities, such as the Hatch, McIntire-Stennis, and Eisenhower Consortium programs usually limit projects to 5, or even as few as 1 to 2 years.

Some university researchers are able to conduct long-term studies. Examples include studies of moose–wolf relations on Isle Royale, directed by Durward Allen (Mech 1970, Peterson 1977), Lloyd Keith's 15-year study of the snowshoe hare (Keith and Windberg 1978), and Fred Wagner's long-term studies of predator-prey interactions in the Curlew Valley, Utah (Clark 1972). Arner has studied the ecology of utility line rights-of-way for 25 years—16 years at Mississippi State University. Long-term projects of this nature at universities are exceptions.

The Subject Matter of Current Research in Wildlife

The Smithsonian Science Information Exchange (SSIE) has incomplete records of research in progress. Academic Media, in cooperation with SSIE, published lists of 1,429 animal ecology projects, and 2,094 fish and wildlife projects for 1972–73. J. Wheatley (personal communication) estimated that there were between 1,340 and 3,000 wildlife projects in these two categories for 1976–78.

Contents of papers published in the *Journal of Wildlife Management* in 1968 and 1978 reflect trends in taxonomic and disciplinary scope of research, but these trends are modified by editorial philosophy (Table 1). Papers on ungulates, gallinaceous birds, and hares and rabbits declined in relative numbers during the decade, while papers on carnivores, waterfowl, raptors, rodents, and pinnipeds increased. There were more reports on ecology, behavior, nutrition, and physiology in 1978, and fewer on basic techniques and control. Briefly, there was a broadening of taxonomic scope, and an increase in "hard" science between 1968 and 1978.

Multidisciplinary research seems to be increasing, as reflected in the increase in authors per article in the *Journal of Wildlife Management* between 1968 and 1978 (1.81 vs. 2.18). Multiple authorship within disciplines and the "publish or perish" philosophy contribute to this trend as well. Also, singly authored papers are not necessarily unidisciplinary.

We believe that multidisciplinary effort enhances the quality and broadens the scope of research. Also, we believe that universities inherently give scientists better opportunities to form multidisciplinary teams, as required to study specific problems, than other performing sectors. This position was supported by Bundy (1978) who wrote: "As the government has a growing interest in all forms of higher learning . . . it shares with universities the good and important belief that no branch of learning should habitually claim to do better alone."

Benefits to the Public from Research in Wildlife

The traditional goals of North American wildlife management have derived principally from consumer interest—commercial and recreational harvest. We have had these goals for several centuries. Effective means of taxing harvesters to support management and research have been developed.

Additional goals have been successively recognized only within the past century. Nongame (noncommodity) management, protection of endangered species,

Table 1. Subject matter of papers published in the *Journal of Wildlife Management,* 1968 and 1978.

	1968		1978	
	Number of papers	Percent	Number of papers	Percent
By taxonomic subject matter				
Ungulates	48	37.2	45	30.6
Anseriforms	16½	12.8	29	19.7
Carnivores	9½	7.4	20	13.6
Rodents	5½	4.3	15	10.2
Galliforms	23	17.8	13	8.8
Raptors	2	1.6	5	3.4
Lagomorphs	8½	6.6	5	3.4
Passeriforms	5	3.9	3	2.0
Columbiforms	3	2.3	3	2.0
Pinnipeds	1	0.8	3	2.0
Charadriforms	2	1.6	2	1.4
Several taxa	0	—	1	0.7
Gruiforms	1	0.8	0	—
Non-taxal, theoretical	2	1.6	3	2.0
Non-taxal, techniques	2	1.6	0	—
Totals	129	100.3	147	99.8
By disciplinary subject matter				
Ecology and behavior	35	27.1	50	34.0
Techniques	35	27.1	29	19.7
Nutrition, physiology, and morphology	11	8.5	27	18.4
Population ecology and theory	24	18.6	22	15.0
Control	6	4.7	2	1.4
Others	18	14.0	17	11.6
Totals	129	100.0	147	100.1
Number of authors	233		320	
Authors per paper	1.81		2.18	

and mitigation are now recognized as goals of wildlife management. Means of taxing beneficiaries to support management and research aimed at these goals are less well developed. There are many examples of the successful application of research results to each of these five goals of wildlife management:

1. Commercial Harvest. The North American wildlife management system maintained raccoons, foxes, and other furbearers as "resources in reserve" during the 1950s and 1960s, based on general wildlife research done in the 1930s and 1940s. The payoff: the U.S. wild-fur industry currently is experiencing an unprecedented prosperity, with values of wild furs produced at about $200 million (M. L. Boddicker, personal communication).

2. Recreational Harvest. Research-based management of sustained recreational activities based upon the harvest of wildlife resources has resulted in far greater populations of elk, mule and white-tailed deer, and pronghorn antelope than existed 75 years ago. There were 20 million hunters in the U.S. in 1975.

3. *Nongame Wildlife Management*. Research on ecology, population dynamics, and other aspects of hundreds of wildlife species that are not harvested, has helped to maintain our nongame resources. There were 50 million wildlife observers and 15 million wildlife photographers in the U.S. in 1975.

4. *Protection of Endangered Species*. Management, based on research, greatly improved the status of the wood duck during the past 60 years. Status of the whooping crane has improved, due to management application of the principle of cross-fostering developed by Rod Drewein from long-term research on sandhill and whooping cranes.

5. *Mitigation*. This application of procedures to compensate for negative impacts of resources development is a recent wildlife-management goal. Mitigation has been applied in some cases, but its general effectiveness has yet to be determined. Current research aims at assessing both compliance and effectiveness. As an example of interest in mitigation, 700 persons will attend the first mitigation symposium, to be held at Colorado State University in July, 1979.

Wildlife research yields benefits to goals other than those of wildlife management. The NSB (1977) listed 13 goals to which the public thought science could make a major contribution. These goals were identified in surveys by the University of Chicago, and included improved health care, control of pollution, improvement in food production, and discovery of basic knowledge about man and nature.

Studies of wild birds and mammals as reservoirs for arboviruses, such as those causing equine encephalitides and Colorado tick fever, are contributing to procedures to reduce human epidemics. Research on the effects of pesticides on wildlife has aided in the control of pesticide pollution. There are many examples of wildlife research contributing to improved food production, including methods of managing vampire bats to improve cattle welfare and reduce the incidence of rabies in tropical America, and development and utilization of rodenticides to control rice rats. Wildlife research has influenced education by revealing new basic knowledge about nature in myriad ways. Contemporary K–12 curricula in science include many examples drawn from wildlife ecology. We could continue *ad infinitum* to cite benefits to the American people resulting from wildlife research. We believe that the financial and intangible benefits of such research greatly exceed costs.

An Evaluation of Current Research in Wildlife

Wildlife research contributes to achieving recognized goals of wildlife management and, in addition, aids in solutions of more general societal problems. National surveys reveal that there are 50 million wildlife observers, 20 million hunters, and 15 million wildlife photographers in the U.S. The 3.5-million membership of the National Wildlife Federation further indicates the high level of popular interest in wildlife.

Wildlife administrators expect research to be applicable to current problems, and research plans to be realistic in terms of funding. Replication is considered desirable, but unnecessary duplication is not. Some managers expect that research priorities should be set according to the urgency of problems. We believe that most current wildlife research is applicable, and is generally realistic in relation to funding. Techniques are improved, and theory is refined, because of replication made possible by the complex system for funding and performing wildlife research.

Emphasis upon applications and urgency is sometimes detrimental to basic research—the development of knowledge for its own sake. Bok (1978) cited several studies demonstrating the vital link between basic science and applications. Basic research was disproportionately important in technological development, applied medicine, and agriculture. There is little doubt that insufficiencies in basic, long-term wildlife research adversely affect management.

Most current wildlife research concerns game, pest, and endangered species. It is difficult to obtain funding for research on nongame and minor game species which are not yet endangered. Currently, wildlife scientists do little research on ecosystems, even though classical ecologists have been doing intensive research in this area for the past 25 years.

Quality of research is evasive to evaluate. The Wildlife Society has named 15 books, monographs, and papers for awards since 1972; 10 published by U.S. authors, and 5 by foreign authors. All but one resulted from long-term field studies, or from lifetime immersion in the subject of the treatise. These publications are symbols of excellence. Evidently, long-term basic research as practiced in Canada, the United Kingdom, Denmark, and Australia is more likely to result in excellence than is short-term research upon targeted objectives.

Another indicator of quality is contribution to basic theory. Population regulation theory is central to much wildlife management. Many important contributions to this theory, such as those by David Lack, Charles Wynne-Edwards, A. J. Nicholson, H. G. Andrewartha, Graeme Caughley, and Charles Krebs, again reflect the value of long-term basic research in an atmosphere of academic freedom.

The United States has the world's largest and best funded group of wildlife scientists. These people work for many organizations of diverse types, and are funded from many different sources. Their accomplishments in applied wildlife research are unexcelled, yet they fall short of their maximum potential in basic research; reasons include: (1) imbalance in ratio of applied to basic research; (2) overemphasis of short-term, at the expense of long-term studies; (3) sub-optimal levels of multidisciplinary effort; (4) overemphasis of commercially important species, as compared to nongame species; and (5) emphasis upon single species, rather than on communities and ecosystems.

Wildlife research in the U.S. has accomplished much during the past, and is still doing reasonably well, in common with scientific research in general. Still, there is evidence of deterioration in American science (National Science Board 1977, Smith and Karlesky 1978), and it seems likely that wildlife research is experiencing this same general deterioration. Insufficiencies in basic research, on which to base applied research on today's urgent problems, is the gravest symptom.

If this deterioration is not arrested by developing means of using fully the capacities of the most brilliant young scientists who wish to enter wildlife research, and of maintaining an environment conducive to productive effort by established wildlife research scientists, it will have serious and long-lasting consequences. The ultimate losers will be American wildlife, and the American people.

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Status of Current Research in Fisheries

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This report summarizes available information on the state of fishery research in the United States. As such, it does not contain complete documentation of all current research undertakings. For example, work at universities is based only on computer listings of National Science Foundation grants, as reported by the Smithsonian Science Information Exchange (SSIE 1979), and on contracts or grants of record from federal agencies. Confidence in SSIE listings should be 80 percent or better, based on cross-references with 97 U. S. Fish and Wildlife Service (FWS) research projects. Research studies conducted by states and by many federal groups were identified through direct contacts. And this information was reported from prospectives of a broad program overview to details of strategy, research approaches, and project funding at some laboratories. Hopefully, this cross section of information will be useful in assimilating and proposing recommendations for future research actions and policies.

State Fish and Wildlife Agencies

The 24 state agencies west of the Mississippi River reported 384 studies in fisheries programs for fiscal year (FY) 78, costing $14,135,000, and grouped as follows: applied research, $8,380,000; surveys, $4,028,000; planning, $1,614,000; and basic research, $113,000. Funding sources were identified as federal, $10,303,000; state, $3,413,000; and others, $419,000.

Sixty-eight percent of total research funding was allocated to fishery biology: management, 25 percent; life history, 15; stocking methods, 10; fish populations, 6; harvest regulations, 4; culture techniques, 3; fish diseases, 3; commercial fisheries, 1; fish control, 1; and other (food habits, endangered species, reproduction, and age and growth), 1 percent.

Thirteen percent of the funding went to environmental studies: water level or flow improvement, 4 percent; stream habitat improvement, 2; water quality improvement, 2; pesticide effects, 2; general pollution, 1 percent; and other (lake habitat improvement, vegetation control, irrigation damage, and thermal pollution effects), less than 2 percent. General studies received 20 percent of the total funding: harvest studies, 9 percent; planning, 8; research techniques, 2; and economic studies, less than 1 percent.

In 12 western states the relative proportion of total funding was expended as follows: research, 12 (4–29) percent; hatcheries, 32 (15–55); management, 43 (11–56); and "other," 13 (1–26) percent.

Twenty of the 26 states east of the Mississippi River reported 312 studies in fisheries programs for FY 78. The total expenditure for research in 19 eastern states, excluding (mostly) marine fisheries, was $8,186,000. Funding percentage was allocated as follows: fishery surveys, 50 percent; habitat surveys, 6; life histories, 5; evaluation of management techniques, 28; fish husbandry, 2; evaluation of environmental impacts and contaminants, 5; and "other," 3 percent. Twelve percent of the studies were considered to be basic research; 92 percent of all research was conducted in-house.

Most state fish and game agencies indicated that lack of personnel and facilities would not limit greater research efforts if more funds were available. State agencies generally acknowledge need for more research, basic as well as applied. State agencies obviously direct their research efforts at applied problems out of necessity; in this light, they also believe that they are in the best position for determining problems and needs that research should address. That is, "every state is entirely capable of conducting its own sustained high-quality research if funds were available."

National Science Foundation (NSF)

In FY 78, NSF sponsored 136 projects in fishery biology and related subjects, at a funding level of $7,547,000. Smithsonian SIE listings show a distribution of research grants as follows: 55 universities (105 projects, $5,613,000), 6 medical schools (6 projects, $208,000), 4 nonprofit research institutes (8 projects, $1,074,000), 2 state academies of science (7 projects, $274,000), 3 research corporations (3 projects, $179,000), 4 museums (4 projects, $159,000), 1 hospital (1 project, $31,000), and an academic society (2 projects, $9,000). The project and funding distribution in FY 78 (SSIE) ranged from 44 organizations, each having a single project (30.4 percent of total funds), to a single organization having 7 projects (21.2 percent of total funds). Major research categories were physiology and related subjects in biochemistry, including behavior, biorhythms, sensing, adaptation-stress, osmoregulation, endocrinology, reproduction, metabolism-respiration—41 studies; interbiotic relationships, such as predator-prey, food chains, and food webs—20 studies; fish collections and systematics—15 studies; marine ecology, general marine biology, and general oceanography—19 studies; genetics, molecular biology, and mechanisms of inheritance—11 studies; and general freshwater ecology, limnology, and population distribution—9 studies.

Minor categories were represented by toxicology-pollution—6 studies; methods and instrumentation development, parasitology, pathology, immunology, and laboratory habitat models—9 studies; and miscellaneous categories, such as ship operation, training and socioeconomics-law—6 studies. NSF sponsored 3 fish-related projects conducted by federal groups: 1 project assessing marine krill resources ($10,000) and 2 on ocean environments ($37,400). Broad project categories in FY 78 were freshwater fishes (47 projects, $1,612,000), freshwater fish-related (39 projects, $2,748,000) marine fishes (33 projects, $1,349,000), and marine fish-related (17 projects, $1,838,000).

Environmental Protection Agency (EPA)

With the responsibilities for setting and enforcing water-quality standards, and for conducting research on causes, effects, and control of environmental problems, EPA expends a major federal effort in freshwater and marine fishery research. Because the agency has regulatory responsibilities (Council on Environmental Quality 1977), its program concentrates on objective water-quality standards that will provide defensible regulation proposals and support adjudication in discharge violations. Fishes and fish-forage organisms are studied to establish water-quality criteria and to set standards for environmental protection. EPA operates "pollution ecology" laboratories in Duluth, Minnesota; Corvallis, Oregon; Athens, Georgia; Narragansett, Rhode Island; and Gulf Breeze, Florida. Several field stations also survey, monitor, and study pollution effects. EPA Laboratories at Ada, Oklahoma and Cincinnati, Ohio use fish-testing protocols in work on urban and agricultural nonpoint-source pollution. Much work is contracted to universities and private research corporations, as well as to federal agencies (FWS, National Marine Fisheries Service, U.S. Department of Agriculture, U.S. Geological Survey, and Tennessee Valley Authority), through interagency agreements.

Current water quality work typically involves in-depth studies of a few key fish and invertebrate species. Information is developed on accumulation rates, acute and time-independent toxicity, and sublethal effects of such trace organic pollutants as pesticides and industrial chemicals, and other toxic substances, including heavy metals. Correlations are made among controlled exposures, biologic effects, and residue dynamics in organisms and simulated or natural habitats. These correlations at "no effect" levels are the basis for water-quality criteria. Laboratory studies include a spectrum of tests for each compound of suspected or known harmful biologic effects, and for each of several key "indicator" organisms. These studies progress from screening-type trials (acute toxicity estimates) to in-depth sublethal effects (life-cycle tests), and to residue dynamics requiring sophisticated analytic chemistry.

This approach in fishery research currently sponsored by EPA has evolved over more than 15 years through collaboration with several research groups, notably the FWS Columbia National Fishery Research Laboratory. Other types of pollutants or water quality factors studies are listed in EPA's *Quality Criteria for Water* (1976).

Some examples can highlight EPA's fishery research program, the types of research currently underway, and the agencies concerned. The Duluth Laboratory, and field stations at Monticello, Minnesota; Newton, Ohio; and Grosse Isle, Michigan, listed proposed FY 79 work on 83 projects at a budgetary level of $5,921,000. All but a few of these projects are studies of pollution influences on fish, forage, or habitats, including methods development and validation, toxicology, water quality, and potential habitat deterioration from energy development, eutrophication, dredging, high pollution fallout areas, and man's influence on the Great Lakes. Of the 83 projects, 38 are contracted to universities ($2,789,000), 3 to state and federal agencies ($325,000), 3 to private research corporations ($532,000), and 36 are in-house ($2,274,000).

Research at Athens, Georgia proposed for FY 79 relates to fish or fish habitat modifications in program areas of fate and transport of toxic substances ($1,485,000); watershed management ($822,000); and sources, processes, and systems ($1,115,000). In the first area, techniques are developed to analyze risks of environmental exposures of toxic substances with information on ecologic effects. Environmental effects are estimated from anticipated quantities of toxic materials entering aquatic ecosystems, and from an understanding of transport, translocation, transformation, degradation, distribution, and accumulation. Tests are conducted to characterize these phenomena, and models are developed to process data according to physical, chemical, and biological characteristics of receiving environments. To improve watershed management, the agency attempts to develop quantitative methods for assessing water-quality problems, sound pollution-control strategies, and techniques to enhance water quality, besides source control. Additional work attempts to improve and enlarge scientific knowledge, methods, and relevant data bases to help predict, prevent, or improve problem areas of discharge, movement, impact, and control of all types of pollutants in aquatic environments.

Research for toxic-substance testing identified in FY 79 at Corvallis included test protocol development and verification with fish and related food-chain organisms ($405,000); development of water-quality criteria for heavy metals and pesticides, interaction between contaminant-induced stress and infectious viral and bacterial diseases, and pollutant effects on lab-scale stream populations (up to $600,000); and a comprehensive ecologic program on effects of nonpoint-source pollution ($2,000,000). The latter program includes 13 in-house projects, 8 university grants, 4 university contracts, and 6 interagency agreement projects. Marine and estuarine pollution research at Narragansett, Rhode Island and Gulf Breeze, Florida totals $8,000,000 per year.

National Marine Fisheries Service and National Oceanic and Atmospheric Administration (NMFS/NOAA)

NMFS is the major federal agency having marine fisheries research and management responsibilities. It operates 21 research laboratories, reporting through four regional centers, with an annual budget of about $52 million, not including operating costs for research vessels. The agency investigates effects of natural and man-induced environmental changes on fish (and shellfish), better fishing gear and techniques to reduce incidental marine mammal mortality, and effects of pathogens and contaminants on all major fish (and shellfish) products.

Research activities also include marine resources monitoring, assessment, and prediction to continually assess resources through surveys, oceanographic programs, and fisheries analysis. This information is used to develop management plans as required by the Fishery Conservation and Management Act (1976), and to prepare, in cooperation with the State Department, analyses of stocks and fishing efforts for international negotiations on fisheries and marine mammal issues. Surveys for marine recreational fisheries participation, catch and effort data will probably exceed $2 million during 1979.

NOAA administers financial assistance to states and universities to help prepare broad criteria and guidelines for managing and developing national fisheries resources. For example, 144 fisheries-related projects in the FY 77 Sea Grant program included research of resource development (41 projects, $1,210,000); socioeconomics and law (28 projects, $666,000); technology (16 projects, $399,000); environment (23 projects, $664,000); education and training (7 projects, $161,000); and advisory services (29 projects, $2,117,000). Additionally, FY 77 Sea Grant funds supported 6 sport-fishery research projects amounting to $150,000. FY 77 funds of over $5.3 million for fisheries-related projects made up about 19 percent of the Sea Grant budget.

NMFS fosters state–federal cooperative research and management, along with integration for multijurisdictional fisheries. Under the Commercial Fisheries Research and Development Act of 1964, NMFS and NOAA reimburse 75 percent of states' and territories' costs for approved commercial fisheries projects. Funds used for fisheries research in this program are now about $3.3 million annually.

Demonstration fishing, shipboard handling, storage studies, marketing research, inspection service, financial assistance, and consumer education are part of NMFS' fisheries development activities.

NMFS' annual expenditure for marine fisheries research, including vessel operation cost but not aquaculture, is about $66 million. Expenditures for marine fishery research from NOAA's Sea Grant and Coastal Zone Management Offices, FWS, and the Marine Mammal Commission increase the annual budget to about $72 million (about 5 percent of the value of the 1977 U. S. commercial landings of edible species).

Tennessee Valley Authority (TVA)

The major charge of TVA is to regulate the Tennessee River and major tributaries for flood control, navigation, and power production. TVA also is responsible for developing and managing programs for fish and wildlife, outdoor recreation, and other activities requiring research in reservoir ecology.

Fishery research by TVA is aimed at evaluating and monitoring environmental impacts and enhancing fishery resources. Monitoring gross effects of high-volume thermal discharges from coal-fired and nuclear power plants provides baseline data on species occurrence, spatial and temporal distributions, relative abundance, migration, growth rates, standing stocks, sport fish harvest, larval fish populations, and radionuclide levels in fish tissues.

TVA's Biothermal Research Station conducts studies of effects of elevated temperature regimes on growth, reproduction, and survival of sport and food fishes, as well as on associated food-chain organisms. Research is conducted to find ways to minimize potential impacts that steam-plant intakes have on fish populations by impinging adult fish on screens, and by entraining larval fish through condenser-cooling systems. Concern over adverse effects of intakes resulted in work on population dynamics, behavior, and the life history of the paddlefish; taxonomy, development, and ecology of fish larvae; and mathematic modeling of larval fish-population and reservoir-production dynamics.

TVA also evaluates water quality and surveys aquatic communities in reservoir tailwaters to assess impacts of hydroelectric projects on downstream uses. This information is the basis for cooperative fishery management investigations with FWS, Georgia, and Tennessee.

In support of its program for enhancing fishery resources and sportfishing, TVA conducts studies to establish guidelines for contructing user-facilities, evaluate results of management techniques, and enhance habitats in streams and tailwaters. Other efforts are directed toward improving commercial harvest methods for minimizing adverse effects on game fishes, and toward helping develop food fish production in operations using waste heat from steam plants.

Research and development listed by SSIE for FY 78 included 5 fish studies funded at $580,000, and 8 fish-related studies funded at $99,000. TVA reports that total research funding in FY 79 is $861,000.

Office of Water Research and Technology (OWRT)

Interior's OWRT, in fiscal years 76,77, and 78, funded 22 studies at 18 universities. A computer list provided by the agency showed relatively small funding levels, averaging $13,800 each for 10 studies in FY 77, and $12,400 each for 7 studies in FY 78. Examples of studies include physiologic ecology, fish health factors, effects of point- and nonpoint-source pollution, population surveys of fish and fish forage, and conceptual model development for management of aquatic resources.

Army Corps of Engineers (COE)

Research projects conducted in FY 78 by COE (as listed by SSIE; funds not reported) fall into 3 broad categories: 22 freshwater fish studies, 30 freshwater fisheries-related, and 4 estuarine or marine fisheries-related studies. These included management studies in 1 or more of the following areas: habitat (2); fish (27); fish forage (12); reservoirs, lakes, or tidal marshes (43); rivers (43); and water quality (30). Of these studies, 25 were conducted by the Water Experiment Station at Vicksburg, Mississippi, and 19 by the North Pacific Engineering Division, Portland, Oregon. The North Pacific group's work mostly concerned monitoring and managing hydroelectric dams on the Snake and Columbia Rivers (e.g., fish losses, migration, spawning, bypass systems, effects of power peaking, and fishway collection). The Vicksburg group reports that work in FY 79 serves environmental and water-quality parameters of operations on reservoirs and southeast rivers. FWS's reservoir investigation group receives "pass-through" dollars ($320,000) for work to develop and evaluate criteria and methods (reservoir releases, etc.) for maintaining downstream aquatic habitats and life. The Water Experiment Station reports that in-house waterway field studies (about $320,000) at 2 sites on the lower Mississippi River and the Tennessee-Tombigbee project are aimed at determining the value of habitats formed by bendway cutoffs, dikes, and revetment structures for feeding, spawning, and nursery areas.

Other Federal Agencies

Agencies such as the U.S. Department of Agriculture (USDA) conduct research that is not strictly related to fisheries but that has management implications in habitat alteration and assessment. For example, the Agricultural Research Service and Forest Service in FY 78 conducted research in at least 16 projects dealing with water resources, runoff, and water quality in streams, lakes, and rivers. The Forest Service has three current studies of silviculture effects on salmonid spawning habitat. Likewise, the U.S. Department of Energy's Battelle Pacific Northwest Laboratory had a small fish-research effort in FY 78.

Research and development projects of the U.S. Geological Survey are not concerned directly with fish, but geophysical and related processes studies have profound influences on aquatic environments. Thus, several research projects conducted in FY 78 may be categorized as "fish-related" in that they deal with water resources, factors relevant to aquatic habitats, and transition zones. This work deals with physical processes and features the environment on a large scale—mostly that of the intermountain west, its major river basins, freshwater environments, shorelines, marine environments, coastlines, and the continental shelf. Pertinent research includes water composition and movement, surface- and groundwater resources, climatology, sedimentary deposits, mineralization, mapping, geologic hazards, modelling studies, and pollution. In FY 78, 22 of 37 projects (SSIE) referring to "freshwater environments and lakes" were considered as fish-related; funding was $1,188,000.

The Smithsonian SIE computer listing for fish or fish-related research in FY 78 did not show projects for the Bureau of Reclamation (BOR). However, BOR and USDA-Agricultural Research Service collaborate with FWS in testing several herbicides (used in canal weed control) for fish toxicity, avoidance, and some chronic effects. These tests are conducted near Denver, Colorado in BOR field-research channels.

Information from other federal agencies sponsoring some research in fishes (e.g., National Institutes of Health, Army biomedical and toxicologic laboratories) was not available.

Universities

Universities contribute greatly to fishery research in traditional roles of training researchers and technicians, formulating and testing biologic hypotheses, and originating technologic advances in research approaches. Some academic institutions appear to be making significant scientific efforts in meeting sociopolitical objectives for protection of natural aquatic resources and aquatic environments. Fishery research can be addressed most successfully at those universities having facilities and expertise to advance fishery science and technology so as to permit us to (1) assess environmental impacts effectively and on time; (2) develop sufficient water-quality criteria to safeguard resources; (3) enhance desirable and suppress undesirable natural ecological processes; (4) achieve multipurpose "optimal yield,'' encompassing abiotic as well as biotic features of ecosystems; (5) incorporate fisheries objectives and constraints into workable regional plans; (6) mitigate deleterious effects of inevitable developments by ecologic techniques; (7) rehabilitate currently degraded major fishery resources; (8) accommodate demands of various fishing interests; (9) design and manage efficient aquaculture enterprises, necessary social and economic infrastructure, and scientific extension services; (10) exclude and (or) control diseases, parasites, and unwanted exotic flora and fauna in a vast continent with an open society; (11) test complex hypotheses through experimental management; and (12) recognize in practice that species other than man also have ''rights.''

Several limitations to fishery research at universities have been proposed. On everyone's list is lack of adequate and steady funding. It has also been suggested that research in North American schools with some fisheries specializations is lagging behind recent sociopolitical challenges and opportunities, for a variety of real or imagined reasons.

Federal funding to universities should provide for basic research, with emphasis on research methodologies that better prepare students to conduct research and management activities for their future employers, and to keep faculty updated with equipment and research technologies.

U.S. Fish and Wildlife Service (FWS)

FWS is the major federal agency conducting research on freshwater and anadromous fishes. Research is carried out at 12 laboratories and 19 biology stations; major goals are to improve sport fish production, increase hatchery efficiency, determine contaminant effects, determine exotic fish impacts, develop control methods for undesired fish, and register fishery drugs and chemicals. Five development centers and two training schools are operated to improve fish culture technology and promote science information transfer. Research is conducted to evaluate acute and long-term effects of many types of environmental contaminants and other impacts on fishes. Research approaches, tools, and methods are developed and applied to assess and prevent various limiting influences on fishery resources. Research complements other FWS activities of technical assistance, enforcement, and production.

FY 78 expenditures for the science and technology base in support of FWS' mission were $11.2 million (fishery resources), $3.6 million (habitat and environment), and $1.6 million (endangered species). Research and development activities were 47.5 percent basic, 32.5 percent applied, and 20.1 percent development. About the same levels are predicted for FY 79.

FWS' Division of Fishery Ecology Research conducted 410 studies within 97 projects in FY 78. Reservoir research (17 projects, $1,051,000) was carried out in five regions of the U.S. to accumulate limnologic data, correlate physico-chemical and biologic variables, and evaluate management protocol. Great Lakes research (15 projects, $2,684,600) included stock assessment in each lake, population dynamics, fish physiology, contaminant dynamics, and limnology. Fish culture research (31 projects, $3,217,700) on warm-water, midrange, and cold-water fishes included husbandry, infectious diseases, genetics, nutrition, and environmental contaminant assessment. Fish-control research (5 projects, $757,400) in support of coastal anadromous, inland, and Great Lakes fisheries included studies on anesthetics, therapeutants, piscicides, lampricides, and other fish-control chemicals to meet federal registration and clearance requirements. Other coastal anadromous and inland fishery research in the Pacific Northwest and Alaska (3 projects, $760,000) included studies on fish health, infectious disease control, and limiting environmental factors. Research projects in 6 areas ($123,000) were begun to assess distribution and status of exotic fishes, biologic requirements, and impact on native species. Environmental contaminant research (19 projects, $3,422,500) included studies of acute and long-term toxicity of pesticides and other contaminants, analytic chemistry, modes of action, contaminant–microbial interactions, field monitoring, residue confirmation analysis, residue dynamics in laboratory and field tests, ecosystem precrisis surveys, and methods development.

FWS' cooperative program at state universities conducted research in program areas of biologic services (43 studies), endangered species (3 studies), environmental contaminant evaluation (11 studies), fishery resources (147 studies), and land and water resources development and planning (8 studies). The FY 79 budget projection for 26 Fishery Cooperative Units and half of the 2 combined Fisheries and Wildlife Units, not including contract or university costs, is $2,224,000.

Most federal authorities governing FWS work are covered by 59 Acts, 2 Agreements, and 4 Treaties (U.S. Department of the Interior 1976). Eight of these, the Anadromous Fish Conservation Act (1965), Cooperative Research and Training Units Act (1960), Endangered Species Act of 1973, Federal Aid in Fish Restoration Act (1950), Fish and Wildlife Act of 1956, Fish and Wildlife Coordination Act (1934), Great Lakes Fishery Act of 1956, and the Mitchell Act (1938), authorize FWS participation in federal grants-in-aid for, and its own efforts in fishery research.

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Research Needs in Wildlife

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Renewable-resource management professions need to formulate management principles that address conservation and sustained yield. Induction and deduction dominate formulation of the necessary guiding principles. Induction is the passing from specifics to generalities; deduction, from generality to specific. Induction has dominated wildlife research and provided management guidelines for specific areas, but is time-consuming and has generally not resulted in tested hypotheses and established principles.

The alternative and more powerful approach is to formulate and test falsifiable hypotheses. Only through repeated failure to reject such hypotheses can the profession develop a coherent body of concepts and principles. We encourage a major shift in wildlife research, from the description of events confounded by uncontrolled variables to a hypothesis-testing approach.

Such a shift would have several important effects. Hypothesis-testing, the use of experimental design, and the control of extraneous variables will generally result in higher quality research. Repeated inductive observations produce much condition-specific knowledge that seldom applies to a new situation. Unlike the inductive approach, repeated failure to disprove hypotheses produces a body of condition-specific knowledge, *and* results in established principles.

Perhaps no single group of professionals is more reluctant to accept generality than wildlifers. A fraction of this reactive energy and of the agency data-sets directed at falsifying a single, well-formulated hypothesis would strengthen and enrich the profession.

We need an accelerated search for generality in at least three dimensions: the big picture, the capacity to prescribe, and generalized prediction models. Major management decisions are increasingly made at regional, national, and international levels. Yet too little attention has been focused on big-picture trends. Second, we need the capacity to prescribe positive, mitigative actions before the fact. Generally we are able only to describe what should have been done for wildlife, or what should be done the next time a development is planned. Third, in many biological and ecological situations a single, independent variable often can explain most variance in an important dependent variable. Yet, rather than invoke the simple, single-factor model that predicts an outcome with 90 percent precision, we spend thousands of dollars measuring covariates with sampling errors of 10 percent or more. Usually the predictions of the generalized model are sufficiently accurate to dispel the need for detailed and expensive elaborations.

A powerful but scarcely tapped approach to wildlife research and management is the development of production functions and trade-off curves. Knowledge of the graphical relations between wildlife abundance or yield and the provision of vital resources would be invaluable to decision makers.

Goals and Objectives

The basic goal in wildlife research is an information base on animals and their habitats that will allow prediction of effects of changes in animal–habitat relationships. The objectives follow:

1. Knowledge of the biology of species and ecosystems to accumulate a long-term data base on wildlife habitats and communities on a national scale.
2. Development of deductive formulation of specific research needs based on an understanding of biological processes, and utilizing long-term data on wildlife habitats and communities.
3. The capability to prescribe land-use designs for various wildlife communities based on predictive capabilities.
4. Predictive capabilities for dealing with effects on wildlife and habitats.
5. Understanding the minimum survival requirements of wildlife species, populations, and communities at all stages of their life cycles.
6. New methods, and improvement of existing methods for rapid transfer of information in a form readily understood and accepted by users.

Inventory

Accurate estimates of population levels and precise measurements of population trends are essential for proper wildlife conservation and management. A continuing knowledge of the constantly changing resource base is fundamental to all other facets of research and management. Our knowledge of the wildlife resource base should extend over seasonal, annual, and long-term time frames; should include populations, subspecies, species, and larger taxonomic groups of all vertebrates; and should be summed for states, larger geographic units, and—in some instances—the continent. There is also need for intensive inventories of entire biological communities. Because population estimation is one of the most troublesome biological problems facing the manager and researcher, the team approach, using new and improved methods, will be necessary.

All methods used to collect and analyze population data need to be examined critically. More realistic models that mimic true field conditions are needed, even though they may be more complex than current ones. We must capitalize on modern statistical methods and computer technology to develop, test, and use more complex and sophisticated mathematical treatments of inventory data. At a time when man's activities are impacting entire ecosystems, quick detection of even slight changes in population levels is essential.

Many census and index techniques that are species- or habitat-specific, or both, have been applied in a wide variety of habitats and on many species. Research on the applicability and suitability of various inventory methods on a range of species and habitats is required. New techniques that take advantage of such technological advances as remote sensing should be developed. For many species and groups of species, suitable techniques are needed to integrate regional, national, and international inventories.

Physiology

Baseline information on physiological parameters is necessary to interpret measured values that may indicate aberrations in natural relationships. Individuals respond before populations; chemical pollutants, for example, infiltrate the physiological mechanisms of individuals, and then cause changes in natality and mortality.

We generally accept that mature animals are adapted for life under the conditions in which they are found. Hibernators, for example, adapt to reductions in food and to greater energy losses due to cold weather by spending several months in burrows with stable thermal environments wherein energy metabolism is reduced, enabling the animal to live on accumulated fat. Such responses are less obvious in white-tailed deer, but metabolic rhythms—with winter depressions—have been documented (Moen 1978). Similar physiological measurements of free-living animals are needed for better evaluations of stress caused by food conditions on the range, predators, human activities, exposure to weather, and other factors in different habitats.

Metabolism is possible only when the nutrients necessary for each biochemical step are provided. Maintenance, activity, and production are all dependent on the ingestion of nutrients in forms that can be broken down and used by organisms. Examples of other needs are additional measurements of various factors to indicate how much energy is required by various species in their different habitats.

Because wildlife managers are interested in populations, basic reproductive characteristics must be recognized and understood. Much is known about the reproductive potentials of wild animals, but much remains to be learned about variations in reproductive rates. More needs to be learned about failures of adults to breed in unfavorable conditions, about the causes for variations in age at first breeding, and about the conditions under which yearlings will breed. Such factors are important for understanding population dynamics.

Much is known about incidence of diseases and parasites in populations of free-ranging animals, but little is known about the roles and impacts they have on natality and mortality, and thus on productivity and population dynamics. Perhaps the greatest interest today in wildlife diseases and parasites is the potential for their transmission to man and domestic animals. The wildlife profession cannot leave development and implementation of "control" methods to others, but must develop effective control programs that have minimum negative impacts on populations of wild animals.

A problem of general concern in the last three decades is the introduction of new chemicals into the environment. These have altered populations of many species. New contaminants will continue to be introduced into the environment. There is a continuing need to monitor these substances and study their effects on the environment and on wildlife.

Behavior

Seasonal differences in activity may be marked (migration, territoriality, reproduction, and others) and are related to seasonal rhythms in hormones. Variations in weather and cover cause short-term changes in activity. Much is known about the activity patterns of many species, but little about the causes of those patterns. Understanding basic mechanisms may have been academic in the past when organisms behaved "naturally" in more natural environments, but becomes more important when environmental contaminants alter basic biochemical functions, resulting in subtle changes in behavior that affect productivity and survival.

Understanding intraspecific relationships is fairly simple when evaluating sex and age differences, because the number of variables is small. Evaluating relationships between species is more complex, because species have different levels and rates of appearance and detection of regulatory factors. All mechanisms mentioned thus far are difficult to evaluate in free-ranging organisms because such organisms are secretive, elusive, and uncooperative.

As more species become rare and endangered, both intra- and interspecific relationships may pose serious problems. For example, rare and endangered species may fall below a "critical mass" and be unable to reproduce normally, and an abundant species may have a negative impact on an endangered species. More knowledge on ways to minimize the negative aspects of inter- and intraspecific relationships in such cases is needed.

Is habitat selection inherited or learned? The simple answer to this question is both. In the past, when ample habitats were available for free-ranging species, such a question would have been academic. Now, with reductions in habitat, we are forced to answer the question of how habitats are selected as we make decisions on the use of every parcel of land and every habitat. It may be that many species, even if they can "learn" to use new habitats, cannot learn as fast as their habitats are destroyed, and will, therefore, suffer a reduction in productivity even though new habitats are provided. Survival of many populations and species depends on their ability to change to meet new conditions.

Production

Physiology and behavior focus on individuals and on collections of individuals into populations and species. Production enlarges the scale to basic groups of organisms: primary producers and secondary producers.

There have been relatively few investigations of factors influencing primary production and secondary production in natural communities. Knowledge of primary and secondary production is important to wildlife managers, but knowing calories or biomass of plants and animals is not enough. An environment that has been polluted, disturbed, and simplified may show high primary and secondary production, but the calories are in the "wrong" species.

If the factors influencing conversion of primary production into secondary production are recognized and their roles understood, one might be able to change, alter, and regulate secondary production of some species of major concern.

All of which brings us back to where we began this section. The physiological and behavioral characteristics of the individuals are the foundations for primary and secondary production. The interrelationships are complex; the need for understanding, urgent. An integrated approach is necessary and must be real and in depth. We can explain these relationships between organisms and their environment only with in-depth understandings of the basic processes.

Regulations of Wildlife Populations

Like most sciences, the initial phases of wildlife science have been dominated by descriptions of the structural aspects of populations: population densities and trends, spatial distribution, habitat preferences, and species associations. The structure of any dynamic system represents only the outcome of many interacting dynamic control processes. Generally speaking, it is impossible to elucidate the relative importance of the controlling processes from simple structural properties. For example, the pyramid too frequently is viewed as an endpoint of the research and used as diagnostic of population well-being. In truth, the pyramid is a confounded portrayal of history, offering hardly a clue as to whether survivorship, reproduction, or some interaction of the two contributed to the outcome. Only by separating the time-dependent survivorship and dispersal functions from reproduction and analyzing them separately can sense be made of the controlling factors. Thus, the emphasis of the research is changed from a description of structure to an understanding of the controlling processes.

It is known, in principle, that birth rates and neonatal survival are more important population-regulating parameters than survivorship through the later stages of life (Cole 1954, Bell 1976). It seems paradoxical that so much more of wildlife management is aimed at increasing the survivorship of wildlife populations (for example, hunting regulations and their enforcement) than is directed at the birthrate function.

More knowledge of the birthrate function is important not only in population regulation but from a practical standpoint as well. Wildlifers must increasingly make judgments regarding the resiliency of populations. Resiliency, in turn, depends heavily on reproductive potential. Without age-specific survivorship and birthrate data it is impossible to calculate key population parameters. Without knowledge of these parameters, it is impossible to speculate on population resiliency or manageability. Twenty years ago Smith (1958) observed that the instantaneous growth rate was an adaptive indicator of environmental harshness for any given species. The instantaneous growth rate can be logically extended to serve as an indicator of manageability. We do not know of a North American wildlife species for which enough data exist to calculate the full range of life table parameters—age-specific death rates and age-specific birth rates (Mertz 1971 and Fowler and Smith 1973 used estimated data).

If the frequency of occurrence of age and sex class and the age-specific birth and death rates are known, two additional lines of research will prove fruitful. Most wildlifers are aware, by anecdote, that small organisms respire greater quantities of energy per unit of biomass than do large animals. Similarly, young animals require greater energy per unit of biomass than do older animals. Few researchers or managers have followed the logical consequences of these principles to the population and habitat management endpoints.

A closely related, but virtually unexplored dimension of population research involves population genetics. Smith et al. (1976) provided a rationale for using genetic criteria to choose population management units. Perhaps an even more compelling issue involves the genetic parameter, effective population size. As populations are reduced to low levels, the consequences of inbreeding and genetic drift increase dramatically. Also, mating does not occur randomly. Thus, without knowledge of the breeding patterns of small populations, a simple count of individuals has little bearing on the effective breeding population size or the gene pool size. The Effective Population Size parameter incorporates the degree of nonrandomness associated with the breeding structure of the population. For example, in certain mammals a harem bull might reasonably serve 50 or more females. From a genetic standpoint, the Effective Population Size is reduced from 51 to only about 5 (Harris and Miller, in press). Bonnell and Selander (1974), Foose (1977), and Flesness (1977) describe the genetic shifts in several large vertebrates due to bottlenecking, inbreeding, and genetic drift. As preserve populations become more isolated, genetic considerations will become more important.

Population Response to Perturbation

Predicting population responses to perturbations involves the gamut of complex interactions previously described. One of the most debated issues is the effect of hunting on wildlife populations. As antihunting sentiment grows, the rationale for sport hunting gives way to argument regarding the impact on the species in question. Few data exist to demonstrate the relationship between harvest and natural mortality. It is unknown what characteristics of the populations or their environments determine the degree of compensation for harvest or control programs. High priority should be given to experimental evaluation of population response to different harvest levels for important game and nuisance species.

Predicting responses of wildlife communities to other disturbances and perturbations will be even more difficult. These disturbances range from the subtle effects of viewing and scientific study to major impacts resulting from clearcutting, reservoir construction, and urbanization. When spanning such a wide gamut of disturbance, simple population studies will have to give way to physiological measurements and the dynamics of entire communities.

Minimum Habitat for Survival

In the future it will be necessary to set more priorities as populations and habitats decline. We can estimate the number of two species and the amount of habitat available for each, but we know almost nothing about the minimum amount of habitat a species, population, or community requires for survival. If forced to choose only one property because of limited funds, we need to know which to buy. We also need to answer fundamental questions for all species as to what factors in habitat—physical and psychological—supply the animal's needs.

How does Habitat Provide for Animal Needs?

There is much information on the requirements of individuals of many species for food and water. We calculate the number of oak trees needed for populations of squirrels, turkeys, and deer—and we may include white-footed mice, blue jays, and woodpeckers, but a host of other species feed on acorns. What happens to the animal community when the acorn crop fails?

Continuing studies of food habits have been made necessary by substantial changes in food habits of species resulting from drastic declines in native habitats and accompanying increases in farmlands and urban areas. Through such studies we can learn how the more successful species cope with shortages of preferred foods.

Habitat also provides thermal values, escape cover (Elton 1939, suggested that visual and scent barriers between predator and prey were among the main ways in which cover reduced predation), nest sites, brood cover, roost sites, loafing areas, and many other values. We know, to varying degrees, something of the requirements of many species for these factors, but we need additional information in almost all cases and the basic information on all of these factors for some species.

Habitat must provide for the total needs of all animals in the community. It has become increasingly clear in recent years that, except for food (provided directly by plants and by the prey species they provide), plant species composition is less important than plant structure and density in a given habitat. Thus, future research in habitat needs should emphasize structure and density. When scarce funds are used to acquire nesting habitat, it is essential that the highest possible number of young be produced per dollar spent.

In the process of learning the minimum amount of habitat a species needs for survival, it is inevitable that much will be learned about how habitat supplies the animal's requirements.

Systematics

Reintroduction of native species has generally been more successful when animals of genetic stock closely related to the original population have been used. Identification of races is especially needed for migratory birds on staging, migratory, and winter habitats. In most cases, managers are unable to recognize races of migratory birds away from the breeding grounds.

Such information is important to managers for both hunted and nonhunted species. Differential hunting pressure on one race can jeopardize an entire breeding population without making a significant difference in the kill where the hunting occurs. A similar situation could develop for a nonhunted species through introduction of a pollutant into the breeding range of only one race. When genetic stocks can be recognized, mortality and natality rates and population trends can be determined for various populations.

The manager and the researcher in the field need to know the answer to this question: "Is there a way to recognize different genetic stocks that are exposed to different environmental conditions, and thus can be expected to show different responses?"

Sociology and Psychology

Knowledge about attitudes toward wildlife is limited. For example, why do attitudes toward hunting range from enthusiasm to indifference, and even to revulsion? Wildlife researchers have been reluctant to pursue research in this area because we are generally not trained in sociology and psychology, and we often share with other natural sciences a disdain for the less objective research methods that necessarily are used by social scientists. However, if we are to gain new insights into attitudes toward wildlife, we must work closely with sociologists and psychologists and develop our own expertise in these fields.

Perhaps, too, we are reluctant to admit the need for information about attitudes and how they are formed. Obviously, if we seek those answers our purpose must be to influence the formation of those attitudes. Wildlife management would then be entering the advertising business—an unknown area we are reluctant to explore much beyond the scope of our current conservation education efforts. Yet we must learn to effectively influence attitudes if wildlife is to compete successfully for public support and for votes on resource allocation issues.

Different factors characterize different types and groups of hunters. Studies similar to Hendee's (1972) multiple-satisfactions approach should be made of such other groups as watchers and antihunters. We need also to examine the attitudes of the vast, much-discussed "silent majority." Are these people really indifferent to wildlife, or are they silent for other reasons? If they are indeed indifferent, research sould seek to determine how this attitude develops, and how we might influence this group to take an active interest in wildlife.

Economics

The importance of economic research, like the importance of sociology and psychology, has only recently been even partially recognized by most wildlifers. Environmental legislation has created a critical need for determining economic values of wildlife so that we can compete on an equal basis with other resource users. Wildlife values are also an essential input for models and other analysis procedures designed to assist wildlife managers in decisions to allocate resources.

Because wildlife and wildlife-related recreational experiences are largely noncommodities, their values must be determined indirectly. We need to explore and develop methods to correct for the inevitable biases that are involved in economic surveys. Wildlife values may be estimated in several ways: gross expenditures, expenditures for transportation and other variable costs, willingness to pay, income foregone (Soileau et al. 1973), and annual replacement values. We need to understand why these approaches lead to substantially different estimates, and we should identify the most appropriate approaches for various uses.

Wildlife has a value to people who are not hunters, yet most efforts to determine wildlife values have been aimed at hunters and trappers. A true picture of wildlife values for use in mitigation and for other environmental protection purposes must include the values to nonhunters as well as to sportsmen. We must also recognize the negative economic impacts of wildlife—for example, damage to crops, damage caused by collisions with automobiles, and diseases transmitted to man and his domestic animals.

Cost-effectiveness models have been applied to management programs in recent years, often without recognizing their limitations. Biological processes must be given mathematical representations to be used in mathematical models. Frequently, these must be crude approximations in order to fit existing linear programming or benefit: cost analysis procedures. More realistic biological representations would make these models substantially more useful. We need better models to determine the cost effectiveness of management programs aimed at enhancing wildlife and controlling wildlife causing damage.

We find it difficult to predict accurately the biological results of a management program, much less the economic impacts. Better models and other analysis techniques, particularly methods that handle nonlinear processes efficiently, would greatly aid efforts to allocate resources and evaluate projects.

Transfer of Technology

The rapid encroachment of urban and agricultural development on wildlife habitats has accelerated the need for effective communication both inside and outside scientific circles. Peer communication is relatively good through refereed journals, but communication of research information to managers has not been effective. The whole area of information transfer needs the attention of professionals trained in communication skills for dealing with the public and with individual managers and administrators working with wildlife biologists. It is not merely a matter of data transmission, but of interpretation of data for immediate use.

Researchers are concerned that data may be misinterpreted by laymen, and that use of preliminary data from incomplete studies may lead to false conclusions. Yet the quick decisions demanded in many management and land-use activities may come without input from research unless data are made available as they are developed. The compromise entails continued strengthening of refereed journal outlets and peer review of work, and greater involvement of researchers in transmitting their findings to management. Researchers must do a better job of identifying individuals, agencies, and pathways to get specific information to the proper people for use at the critical time; if they do not, many of our best efforts will remain unused.

Because researchers cannot depend on scientific journals to pass their messages on to users, we should build reporting mechanisms into ongoing research, with the researchers as participants. The surest way for research scientists to be satisfied that their information is correctly interpreted is to involve them in explaining their results to individuals other than their peers. This effort may require close working relationships with journalism and other disciplines that train people for these tasks. Better use of journalism techniques may be adequate for transferring information to the general public, but these techniques—as usually employed—are not adequate for transferring information from wildlife researchers to decision makers. For this task, we might train professional analysts analogous to the professionals found, for example, in the research departments of investment banking firms.

Specific research on technology transfer should follow case histories of resource management problems, ongoing investigations of these problems, decisions and actions taken relative to the resources in question, and interactions between researcher and manager throughout the process. Scientists and managers must appraise the flow of information between them. Nothing frustrates individuals or the wildlife profession more than does the failure of results of completed work to arrive where they are needed, on time and in a usable form.

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Research Needs in Fisheries

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The Fishery Conservation and Management Act of 1976 is one of the most important pieces of legislation related to fisheries ever passed in this country. The Act not only established the 200-mile management jurisdiction zones for coastal fisheries, but also set national standards for fishery conservation and management—standards that can only be met through extensive research on fish and fisheries. The Act states that any fisheries management plan and any new regulations must adhere to the following standards:

1. Conservation and management measures shall prevent over-fishing while achieving, on a continuing basis, the optimum yield from each fishery.
2. Conservation and management measures shall be based upon the best scientific information available.
3. To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
4. Conservation and management measures shall not discriminate between residents of different States. If it becomes necessary to allocate or assign fishing privileges among various United States fishermen, such allocation shall be (A) fair and equitable to all such fishermen; (B) reasonably calculated to promote conservation; and (C) carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.
5. Conservation and management measures shall, where practicable, promote efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.
6. Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

7. Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

By and large, these standards comply nicely with the "new" principles of resource management advocated by Holt and Talbot (1978). It is obvious, however, that both the standards set forth in the Act and the principles of Holt and Talbot are more ideal than real at present. Yet the recognition and wide acceptance of such ideas as optimum yield, multispecies management, and nonconsumptive values means that reality can now at least begin to approach the ideal. However, the standards established by the 1976 act can only be achieved by increasing the complexity of management strategies, since ultimately we will be managing and sustaining communities of organisms rather than just species. Part of this increased complexity must be the result of the development of alternate management strategies for each situation, to enable optimal use of each community or ecosystem.

In many situations, the new management strategies should favor recovery of biotic communities damaged by overexploitation and other factors, and perhaps even creating new communities where new habitats have been created. Development of complex, alternate management strategies for individual fisheries and communities, as well as development of more general principles, applicable where it is not possible to develop adequate specific management plans, will require more and better information on the populations and communities being managed. This information can only be obtained through expanded fisheries research programs. Therefore, the purpose of this paper is to establish how varied information gathered in research programs is used in fisheries models, and to describe the kinds of research needed to improve management of fisheries.

Use of Models

In general, a model is an abstraction of a system. Although models may be physical, graphical, verbal, or mathematical, most fisheries models are of a mathematical nature. Models utilized in fisheries science can be grouped to include those concerned with one or several components (organisms, environment, and man).

Models of an exclusively biological nature are the well-known fishery population dynamics models of single-species systems, including the Schaefer, Beverton-Holt, and Ricker models. Much of the extensive population dynamics literature of fisheries science is related to these models. Recently there has been activity in extending these model types to multiple species; sophisticated examples are the multiple-species extension to the Beverton-Holt model (Anderson and Ursin 1977), and the DYNUMES model (Laevastu and Favorite 1978).

It is becoming increasingly clear that wise management of fishery resources requires a consideration of the total aquatic ecosystem in a given region, since the components of the system interact and the fishery for one species may affect abundance and distribution of other species. To this end, ecosystem models are becoming increasingly common in fisheries science. However, it should be recognized that because of data, conceptual, and computational limitations, aquatic ecosystem models cannot yet be viewed as reliable predictors of system behavior up to the level of fish stocks.

In addition to the above-mentioned components of biota and the environment, man has been included in our modeling concepts to form bioeconomic models. These models are very important to commercial fisheries management, but have received little attention in recreational fisheries.

The above models can be developed either as deterministic or stochastic (probabilistic) forms. It is anticipated that considerable progress will be made with stochastic modeling in the future of fisheries science. However, this effort must be coupled with certain empirical alternatives, such as those suggested by Orach-Meza and Saila (1978), to provide short-term information for management decisions.

Regardless of complexity, all types of models are only as good as the accuracy of their assumptions, which in turn are based on the modeler's experience and on data gathered in the field or laboratory. The better the data, the more reliable the model (assuming the appropriate assumptions have been made), and the easier it becomes to improve old models and create more sophisticated new ones,including general models that can apply to a variety of situations. These models should closely simulate the behavior of fisheries and fish populations to be usable in determining management options. In addition, as more accurate and complex models are developed, it will become increasingly possible to select model elements of use in developing simpler, more practical and robust models for the fisheries manager. Results of these "working models" can then be compared to predictions of more complex simulation models, and further rounds of improvement can ensue, until both models produce essentially the same results. The final models should thus be simple enough on one hand to fulfill the needs of the fishery manager, and complex enough on the other to satisfy the researcher that the management program is based on a high degree of realism, minimizing surprises and maximizing optimal use of resources.

Research Needs

The research needs of fisheries fall into 10 basic (if somewhat arbitrary) areas: (1) inventory, (2) systematics, (3) genetics, (4) physiology, (5) behavior, (6) population ecology, (7) community ecology, (8) sociology and psychology, (9) economics, and (10) fisheries technology.

Inventory

One of the most basic needs of resource managers, especially if management is to advance beyond the species level, is to determine just what is being managed. Ideally, a fisheries management plan should include consideration of all elements of the ecosystem of which the population of interest is a part. While this may be impossible, at least the major elements of each system should be known. There is a need to determine the basic distribution, abundance, and habitat requirements of the organisms in aquatic systems in the following order of priority: (1) threatened species, (2) economically important species, (3) species indirectly impacted by fisheries, and (4) species likely to be little affected by man's activities in the immediate future.

Threatened species are those in immediate danger of becoming endangered or extinct unless some positive action is taken. They are listed as top priority partially because of the Endangered Species Act of 1973, but also because they cannot be replaced. Most threatened species are nonresource species; justifications for preserving such species are given in Ehrenfeld (1976).

Economically important species can be placed in three categories: (1) unexploited, (2) exploited, and (3) pest species. There are few unexploited or lightly exploited species, but they should be given top priority for development of management plans and research among economically important species. This would make it possible to avoid the mistakes made on species already exploited, and to provide information on the behavior of populations under exploitation that can be applied to fisheries for which pre-exploitation data are slight or lacking. Exploited species are now, and undoubtedly will continue to be the main focus of fisheries research, since so much basic information is still lacking on most species. This is especially noticeable for those species that have been heavily exploited only in the past 20–30 years. Concern for pest species is a relatively new phenomenon, resulting primarily from introductions of exotics (carp in shallow lakes, sea lamprey and alewife in the Great Lakes) or from perturbations of the environment by man (nongame species in trout streams regulated by dams). Much needs to be learned about the impact and control of pest species.

Species indirectly impacted by fisheries are many, but poorly known, since research has tended to concentrate on the economically important species in each ecosystem to the near exclusion of others. Yet removal of selected species from a system is likely to have severe consequences for the system as a whole: removal of predatory fishes may increase the number of planktivorous fishes while, conversely, removal of plankton-feeding fishes may cause a decline in predatory fishes, as well as in fish-eating birds and mammals. Dramatic faunal shifts as the result of exploitation are well known (Rounsefell 1975), and ultimately these shifts may greatly affect the ability of exploited species to maintain their populations.

Species likely to be little affected in the immediate future, although of lowest priority, still deserve some attention, if only in distributional studies, since such species may be affected in the more distant future either directly or indirectly by exploitation. More importantly, such species may be the ideal animals with which to monitor population trends since their populations would presumably be fluctuating primarily in response to environmental fluctuations, including man-caused disturbance, rather than exploitation. Information derived from studies of such species could thus be useful in predicting the impact of environmental fluctuations on exploited species, and help to avoid disasters such as the collapse of the Pacific sardine fishery as a result of heavy fishing during a time when environmental conditions prevented adequate recruitment of young fish.

Systematics

One of the standards set forth in the 1976 Fishery Conservation and Management Act is that stocks of fish should be managed as units. To do this, the stocks must be identified. When the stocks are synonymous with species this is no major problem, but most species have many separate populations that should be managed individually, especially because the populations often have characteristics that represent adaptations to local environmental conditions. It is important to be able to identify these stocks of fishes, since by treating several stocks as one it is possible to severely overfish one stock while only lightly exploiting another. Thus there is a real need to conduct taxonomic studies on species in the same order of priority as listed in the previous section.

Examples demonstrating the usefulness of systematics are numerous. Studies on anadromous pink salmon (*Oncorhynchus gorbuscha*) have demonstrated that not only do individual streams have distinct populations, but the runs that occur on even and odd years are distinct, as are runs that occur at different times of the year. Many local or seasonal spawning runs were nearly eliminated because early fisheries did not recognize the distinctness of the runs. As fisheries expand, studies are needed to prevent the further extinctions of distinct populations. For example, Saila and Flowers (1969), studying geographic variability in the American lobster (*Homarus americanus*), demonstrated that offshore and inshore populations were distinct morphologically (although some overlap existed seasonally in some areas) and therefore could not be managed as one population.

Genetics

Studies of the systematics of fish populations have revealed that one impact of fishing and other environmental perturbations is a change in the genetic composition of populations. Genetically distinct populations of salmonids, for example, have been destroyed through overfishing or through hybridization with introduced stocks, often to the detriment of local production. One research need in fish genetics, therefore, is the identification of desirable traits so they can be maintained in, or restored to these local populations. Moav et al. (1978) suggested further that genetic manipulation of wild populations of fish is both possible and desirable, to counter the negative effects of fishing; they claim that "genetic deterioration" may have been a major cause of the apparent permanent collapse of some fish populations following overfishing. Such ideas need to be carefully evaluated and tested. In addition, genetic research may be able to produce strains of fish with improved survival and growth in polluted waters, reservoirs, or other disturbed environments. Similarly, such research can produce strains that have characteristics favored by managers or fishermen (especially sport fishermen), such as increased or decreased catchability, rapid growth under special conditions, or attractive coloration.

Some such recent advances have included use of hybrids, including splake (brook trout × lake trout) and hybrid sunfishes (*Lepomis* spp), in situations where their special growth characteristics and inability to reproduce make them more desirable than the parent species. On the opposite end of the spectrum, geneticists have issued warnings that indiscriminant introductions may lead to the swamping of gene pools. For example, stocking the Florida strain of largemouth bass (*Micropterus salmoides floridanus*) into more northern waters may ultimately be detrimental to bass populations because of the strain's presumed genotypic lower tolerance of extreme environmental conditions (Childers 1975).

Behavior

Studies of fish behavior often have immediate pay-offs to fishermen by telling them when and where to fish as well as how to fish selectively for species or sizes.

However, even more important in the long run are studies that yield information on which to base predictions of future behavior. Of particular import are studies of (1) daily movements and activity patterns, including time and energy budgets; (2) seasonal movements and activity patterns, including migratory patterns; (3) factors affecting successful spawning; (4) the function and the impact of fishing upon schooling behavior; (5) aggressive, symbiotic, predatory, and other interactions between and within species; (6) feeding behavior, including prey selection, particularly in relation to changing prey availability (optimal foraging); and (7) mechanisms of microhabitat selection (i.e., how fish select their proper place in the environment). All of the above behavior patterns need to be studied in their "pure" state, and in relation to how they change in response to exploitation, pollution, and natural environmental changes.

Studies of behavior have provided many insights useful in determining factors regulating populations, such as the knowledge that in many salmonid streams space may be more limiting than food because of the demands of territorial behavior (Chapman and Bjornn 1969), or the indication that the schooling of an uncommon species with an abundant, heavily fished species may prevent the uncommon species (such as the California sardine) from ever building up large populations, even when conditions are favorable (Radovich 1979). A perhaps unanticipated benefit of basic behavioral studies has been the use of special chemicals to induce salmon to home to a hatchery or processing plant, based on the discovery by A. Hasler and his students that salmon find their way back to their natal spawning streams through their detection of each stream's unique "odor."

Physiology

Physiological studies are important because they can explain why fishes respond as they do in growth, behavior, mortality, or distribution, to changes in the environment, including those created by fishing or other disturbances. By understanding (1) how fish respond to the chemical, physical, and biological factors of their environment, and (2) what the limits are for these factors for optimal growth and reproduction and for severe stress and death, it is possible to predict when and where fish will be found (cf Barkley et al. 1978). In some cases modification may be possible to make the environment more suitable for fish (or to prevent changes that would make it unsuitable). A good understanding of fish energetics, nutrition, and metabolism also is important in order to make accurate estimates of production and to develop realistic stochastic models of fish communities.

One of the best examples of the usefulness of physiological studies in fisheries management is the metabolic research initiated by J. R. Brett. His studies of metabolic rates, along with studies by others who have adopted his techniques, have proven to be highly useful, for example, in the design of fish ladders and culverts that allow fish passage. Thus Jones et al. (1974) determined critical velocities that prohibit passage of different size-classes of 17 species of fish through a 100-meter culvert, so that a new highway could built with minimal disruption of local fish fauna.

Population Ecology

Population ecology is one of the most difficult aspects of fish biology to study, mostly because of problems involved in sampling fish populations adequately.

Nevertheless, population ecology is so important that fisheries research programs have tended to concentrate in this subject area. Much of this effort has been directed at determining sizes and fluctuations of exploited fish populations, and at examining age structure and growth rates to arrive at some idea as to whether the population is declining, stable, or increasing, and the impact fishing is having upon that population. In particular, much effort has gone into examining the relationship between recruitment of fish into a fishery and size of the parent stock. The first general model of this relationship was developed by Beverton and Holt (1957). Although this model was applied successfully to some fisheries, its application to many others was disastrous, because the model indicated that there was usually little relationship between size of parent stock and recruitment. The result was "recruitment overfishing" (Cushing 1973), and the rapid decline of a number of fisheries. This experience points out the still existing great need to develop models of stock-recruitment relationships and to test these models experimentally on individual fisheries. An example of such a massive experiment is the deliberate overfishing of yellowfin tuna, now in progress, which will presumably determine if there is a strong relationship between size of the adult populations and number of new recruits.

While the study of relationships between stock and recruitment obviously is enormously important, it is also obvious that the reasons for such observed relationships need to be understood as well. This is particularly true since these relationships are seldom straightforward, primarily because many, if not most factors affecting survival of larval fish are independent of the abundance of the larvae. A successful year class may be dependent upon (1) the larvae finding prey of suitable size and nutritional value, present at the right time at densities sufficient to assure survival over some short critical period; or (2) a low enough density of invertebrate predators to keep predation from becoming excessive. Such biological factors are ultimately regulated by environmental factors, including currents, upwelling, and water temperatures. As the importance of these relationships becomes apparent, more research is being devoted to mechanisms regulating growth and survival of larval fishes, but only a small number of species have been examined, and still fewer are well understood. Even with more advanced life history stages, much basic information is lacking on factors affecting population regulation for all but a handful of species. Obviously this information will have to be available before realistic models of fisheries can be developed.

Community Ecology

Ultimately, fisheries management should be at the community or ecosystem level. For one reason, as more species are exploited, more conflicts arise, since exploitation of one species affects populations of another. For example, the recent management plan developed for the northern anchovy off California must consider not just the impact of the fishery on the anchovy but also impacts on predatory sport and commercial fishes that feed on the anchovy, and on seabirds, including the endangered brown pelican. Even this plan—unusual in its efforts to take into account many biological and economic elements—does not consider other potential interactions among fishes and invertebrates in the California current that may be affected. One reason is simply that so little is understood about this system, even though it is one of the better-studied marine systems. Most other systems—both marine and freshwater—are also poorly understood, although we probably know more about temperate freshwater systems than we do about most marine systems. In many cases, we do not know all the species present, much less their population dynamics and interactions with other species.

Before management of communities can be effective, we must first locate those communities and define their constituents. Once a community is defined (often an arbitrary decision, for ease of data gathering), an understanding of its working mechanisms requires description of such species interactions as the roles of (1) interspecific competition, including that resulting from species' introductions; (2) intraspecific interactions; (3) predator-prey interactions, including predation by introduced species; (4) symbiotic interactions, including parasitism and disease; (5) environmental fluctuations in determining community structure; and (6) the impact of exploitation on community structure. From such information, it should be possible to construct a descriptive model of each community.

However, while highly desirable, such a model is also difficult and time consuming to obtain. One major way to circumvent these difficulties is by the study of energy flow through systems (the trophic structure of communities). While studies of production have proven to be very useful in fisheries, especially in estimating the total yield of fish possible from a region (Rounsefell 1975, Cushing 1975), the resulting models are not particularly species-sensitive, except in areas where most of the energy flows through a small number of species (such as in the anchoveta fishing grounds off Peru). Ideally, models of communities should be based on both trophic structure and species structure, fully incorporating the bioenergetics of the individual species involved.

Besides modeling of individual communities and ecosystems, one goal of research at this level should be to determine what factors influence community structure. Connell (1978), for example, discussed some of the conflicting theories of community structure, and pointed out the importance of random events in determining the complexity of some communities. Such ideas need to be tested for their general applicability. There is also a need for general studies on the relationship between community complexity and environmental heterogeneity. Such studies could, for example, result in improved designs for artificial reefs, as well as providing the basis for models of the effects of pollution on aquatic communities.

Perhaps the most complete and systematic studies of fish communities undertaken with the idea of developing management models have been those developed for reservoirs of the southern United States (Jenkins 1967, Jenkins and Morais 1971). These studies have led to the development of a series of multiple regression formulas that can be used to predict fish standing crops and angler harvest and effort in reservoirs (Leidy and Jenkins 1977). The models being developed for reservoirs require extensive information on the biology of various fishes, including feeding habits and digestive rates, rates of reproduction, recruitment, harvest, growth and mortality, estimates of carrying capacity and production, respiration rates, temperature tolerances, and fish chemical composition. Obviously, acquiring this information takes enormous effort, but the payoffs in terms of developing management strategies should more than offset the costs, particularly as reservoir fisheries increase in importance.

Sociology and Psychology

It has become increasingly obvious that fishermen constitute one of the factors most frequently neglected by fisheries models. Much effort is expended to evaluate the effectiveness of fishing gear, and the biology of the species being exploited, but little has been done to determine what motivates a fisherman as to when, where, and how he fishes (except for some stream-trout and other sport fisheries). Since the motivations and strategies of fishermen may in the long run have as much impact on fish populations as any other factor, it is important that they be understood (Anderson 1978, Larkin 1978). One particularly important reason for understanding fishermen is their great influence over setting regulations.

The most sophisticated management plan in the world would be worthless if fishermen did not abide by it, or attempted to circumvent it because the plan did not suit their real or imagined needs. Thus, understanding the motivations of fishermen could lead to better decision-making procedures involving fishermen, fisheries managers, and societal representatives, and ultimately to more rational fisheries management.

An example of the importance of considering the needs of fishermen in a management plan was given by Acheson (1975), in his study of the Maine lobster fishery. Acheson notes that lobster fishermen are highly territorial in their fishing, and are members of close-knit communities. These attributes made it likely that "any attempt to decrease fishing effort by a moratorium on fishing, by taxation, or by the imposition of biological controls (e.g. raising the carapace length) would be strongly resisted. On the other hand, a trap limit and limited entry scheme are consistent enough with some institutional features . . . that they would receive substantial political support (p.653)."

Walters and Hilborn (1978: 176–177) observed that psychological and sociological problems in fisheries management are not confined to fishermen, but are also present among managers and researchers. They note that managers are often unwilling to change management strategies because of a "combination of justifiable risk aversion by decision makers, a deplorable fear on the part of many resource scientists of having their initial predictions proved incorrect, and a proper concern by both that overexploitation may lead to irreversible collapse." For similar reasons, managers may adopt the most optimistic predictions of potential harvest, may not often enough review and revise the parameters fed into fisheries models, and may be reluctant to consider seriously new interpretations or analyses of fisheries data.

Economics

Gulland and Robinson (1973: 2043) pointed out that ". . . the objectives of fishery management are essentially economic, and the effects of management action have repercussions on important economic magnitudes such as employment, income, and the welfare of fishing communities generally." Despite this fact, management plans and studies are developed largely by biologists, who often do not have a good grasp of the economic effects of their actions. In particular, the orientation of managers tends toward finding ways either to increase the catch or to limit it in some way, with little regard for the economics involved.

Yet, in commercial fisheries, for example, the greatest benefits of a particular management decision are more likely to be in reducing costs than in increasing catches (Gulland and Robinson 1973). Thus one of the needs in fisheries research is the development of models that take into account both the biology and the economics of the fishery, in an effort to optimize use of the resource for benefit of the fishing industry, the consumer, and the resource itself (MacKenzie 1973).

One major problem with many fisheries, particularly those in inland waters (including bays and estuaries), results from economic conflicts that arise with competing uses of the environment. For example, in most reservoirs fisheries are generally considered to be of minor importance compared to other competing uses of the water, preventing development of fisheries to their full potential. Similarly, salt marshes and other coastal habitats have been severely altered because their values to fisheries have not received high priority. Conflicts are also arising in the use of bays and estuaries for aquaculture, and in the use of streams for "ocean ranching" of salmon. There is thus a need to find ways to resolve these problems of competing uses; one way is to determine the true value, real or potential, of these environments for fisheries. It is obvious, however, that even under the most optimistic scenario the value of fisheries in many of these situations will prove to be far less than the competing value. For these situations it will be necessary to develop management schemes that will optimize the use of the waters by all parties concerned.

One aspect of this general problem that is difficult to resolve with economics is the maintenance of nonresource species—species which have no immediate value to man, but which may disappear from aquatic environments managed strictly for their economic yield to man. As Ehrenfeld (1976) pointed out, most arguments advanced to justify saving such species are attempts to convert them into resources (e.g., their undiscovered values or their value as "works of art"), and such arguments are rarely convincing in the face of short-term economic considerations. Although perhaps more in the area of religion or philosophy than economics, there is a need to develop value systems for nonresource species that will prevent them from becoming extinct in the face of economic pressures.

Fisheries Technology

In general, research needs in fisheries technology are aimed at finding ways to optimize resource utilization, in a manner that will resolve some of the conflicts existing between the biology, sociology, and economics of fisheries management. Research needs to be conducted in a number of diverse areas, by both public agencies and private concerns, for development of:

1. gear that is more selective for species and size classes of fish, so that management plans sensitive to the often-conflicting needs of many species in one area can be developed and carried out;
2. fisheries technology appropriate for less-developed countries, to increase local protein availability without depleting resources;
3. processing technology to make species currently unacceptable as food (especially in North America) more acceptable, in order to reduce waste in fisheries that discard "trash" fish;

4. better means for using or regulating "nuisance" populations of fish, a problem perhaps more imagined than real but of some concern to managers of inland waters;
5. improved sampling techniques, in order to make possible more accurate and precise estimates of the fish populations at various life-history stages; and
6. well-defined monitoring strategies and techniques to determine the impact of fisheries, pollution, and other environmental perturbations on communities and ecosystems.

Conclusions

Estimates of the maximum sustainable annual harvest of fish and invertebrates from the sea indicate that this limit has been reached, or will be soon. The picture for wild populations from inland waters is probably similar, although inland fish production can be (and is) greatly enhanced through the construction of new environments, particularly ponds and reservoirs, and through aquaculture. The standards of fisheries management stated in the Fishery Conservation and Management Act of 1976 are one recognition of the fact that we have arrived in the era of limits, and must carefully husband the resources we still have. Rational long-term management of fisheries that optimizes allocation of the resources among the many and often competing users can only be possible if adequate information on the fish and fisheries is available. As this report indicates, this information must come from a wide variety of sources and approaches. For most populations, adequate information to determine how to maintain those populations at their present level, much less improve them, is not available.

If sufficient information does not become available for many fish populations in the near future, more declines likely will occur, with widespread economic and social consequences—and perhaps with permanent damage to fish populations and communities. The present fisheries establishment of the United States, with its low level of funding (compared to the long-term value of the resource), lacks the resources to conduct research necessary to provide information for optimal management. The need for funding for fisheries research is particularly acute at our universities, many of which function as the principal regional research centers. The facilities and expertise available at universities should be developed and utilized in fisheries research, just as they are in such fields as chemistry, physics, medicine, forestry, and agriculture. Providing substantial funding for such research is necessary if our fisheries and fish communities are to be maintained for continuous future use.

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The Role of Federal Agencies in Fish and Wildlife Research

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Numerous groups have been organized to promote research, discovery, and application of knowledge to fish and wildlife resource problems. To varying degrees these objectives have been met by universities, government agencies, special research institutes and foundations, scientific academies, museums, and private conservation and industrial organizations. The principal federal institutions that are currently devoting major attention to fish and wildlife research and management are the Fish and Wildlife Service (FWS), National Park Service (NPS), and Bureau of Land Management (BLM) in the Department of Interior; the Forest Service (FS) in the Department of Agriculture; and the National Marine Fisheries Service/National Oceanic and Atmospheric Administration (NMFS/NOAA) in the Department of Commerce.

The FWS, NPS, BLM, and FS administer about 700 million acres (285 million ha) of public land and water, and have as one of their primary missions the wise management of fish and wildlife and other renewable natural resources on these lands. The NMFS/NOAA manages no public lands, but is the major federal agency with research and management responsibility for marine fisheries. Other federal groups have some level of responsibility or concern for fish and wildlife, either because it occurs on lands they administer, or because they must comply with various federal laws. These agencies include the Environmental Protection Agency, Bureau of Reclamation, Army Corps of Engineers, Tennessee Valley Authority, Federal Aviation Administration, Maritime Commission, and the departments of Defense, Transportation, and State. A complete description of the activities of these agencies is beyond the scope of this paper, but it is appropriate to discuss the missions and research capabilities of the major fish and wildlife resource managing agencies.

Fish and Wildlife Service

The Fish and Wildlife Service is authorized to conduct research under the Animal Damage Control Act, Migratory Bird Treaty Act, Fish and Wildlife Coordination Act, Cooperative Research and Training Units Act, Endangered Species Act, National Museum Act, and the Marine Mammal Protection Act. Although authority exists to conduct broad ecological investigations, major emphasis is on migratory birds (especially waterfowl), animal damage control, fish culture, endangered species, and environmental contaminant–wildlife relations.

This agency's land management responsibility includes 33 million acres (13.4 million ha) in 390 National Wildlife Refuges, 1.6 million acres (.65 million ha) in 131 waterfowl production areas, and 11.8 million acres (4.8 million ha) in two Alaska National Monuments. Research on fish and wildlife is carried out by 770 full-time permanent employees at 25 major facilities, 60 satellite field stations, and 50 cooperative research units. In 1979, the appropriated FWS research budget was about $30 million, with an additional $3–5 million from other sources. Planning, coordination, and administration of the program is centralized in Washington, D.C., under an Associate Director for Research.

National Park Service

Authority for fish and wildlife research in the National Park Service is vested in the Act of 1872 which established Yellowstone National Park, the Organic Act of 1916 that created the NPS, various Congressional Acts establishing individual parks, and Presidential Executive Orders creating monuments. These authorities to conduct research do not extend beyond park and monument boundaries.

Natural resources research is conducted in the nearly 200 natural area units representing about 72 million acres (29.2 million ha) of the National Park System. Research in natural history and natural resources management is carried out in the NPS under the aegis of the Chief Scientist of the Service in Washington, D.C., as a part of the Service's science and technology program. The Chief Scientist (an Associate Director of the NPS) administers the programs of Park Science and has technical (but not administrative) supervision of 9 regional chief scientists, through which he furnishes technical supervision to about 100 field- and university-based researchers and their respective programs. Many large natural area parks have the services of one or more research natural scientists, and researchers located at universities each have programs, usually involving several park areas. University researchers are either university employees working under contract to the Service, or Service employees stationed at the university. In either case, the usual arrangement is in the form of a Cooperative Park Studies Unit produced by a memorandum of agreement between the Service and the university; there are approximately 40 such units.

The current level of natural history and natural resources research in the National Parks represents about $10 million of Service funding, all related to the management of natural areas, natural resource preservation, and natural area interpretation. Approximately $10 million is expended additionally for research in parks by university and other institutional programs, because protected park areas offer such excellent conditions for the study of natural ecosystems. The NPS objective in natural area parks is to maintain, in perpetuity, those natural ecological conditions that would now be extant were it not for the advent of modern technological man and his cultural accoutrements.

Bureau of Land Management

Fish and wildlife research on BLM-administered lands is authorized specifically by several recent Acts, namely the Federal Land Policy Management Act and the amended Sikes Act, Public Law 93–452, both of which authorize research as one of the procedures that may be utilized to protect, conserve, and convey public lands, and to enhance wildlife, fish, and game resources on these lands. BLM, nevertheless, relies primarily on the capability of other government agencies, institutions, and individuals to conduct needed research. Contracts and cooperative agreements are the mechanisms through which research projects are initiated and funded. In addition to its sponsored research, BLM permits or authorizes research on public lands by other groups and, in order to encourage such research, has set aside about 20 research natural areas totaling 50,000 acres (20,250 ha).

Forest Service

The Forest Service has conducted its research program, including fish and wildlife since 1928, under authority provided in the McSweeney–McNary Act. This Act also authorized the FS to cooperate with others, and to establish regional forest experiment stations. The Forest and Rangeland Renewable Resources Research Act of 1976 superceded McSweeney–McNary and is now the basic authority for FS research. Other legislation enabling the FS to carry out its research program includes the Cooperative Forestry Research Act (McIntire–Stennis), the Forest and Rangeland Renewable Resources Planning Act (RPA), the Hatch Act, and the Sikes Act.

FS operates a large and diversified research program, emphasizing silviculture, forest protection, rangeland management, fish and wildlife habitats, recreation, watershed protection and management, forest products and engineering, and economics. Much of the research undertaken on silviculture, forest protection (fire effects, insects, and disease), rangelands, recreation, and watershed protection contribute to an understanding of fish and wildlife ecology.

FS administers 187 million acres (75.8 million ha) in 155 National Forests, 19 National Grasslands, 17 Land Utilization Projects, 92 Experimental Forests and Experimental Ranges, and 99 Research Natural Areas. The research program is carried out by 2,700 full-time researchers including 980 research scientists (GS–11 or above), 8 forest and range experiment stations, 1 forest products laboratory, 1 institute of tropical forestry, and 82 laboratories. Funding for FS research in 1979 was $108 million, with about $6 million allocated specifically for fish and wildlife habitat research. Administration and supervision of the research program is through the Chief of the Forest Service to the Deputy Chief for Research to the Research Station Directors.

National Marine Fisheries Service/National Oceanic and Atmospheric Administration

This agency conducts research on marine fisheries, primarily under the Commercial Fisheries Research and Development Act and the Fisheries Conservation and Management Act. Research activities include marine resources monitoring and assessment, evaluation of environmental changes on fish populations, and development of more effective commercial fishing gear and techniques. NMFS/NOAA operate 21 research laboratories through 4 regional centers and, in fiscal year (FY) 1978, expended about $66 million on marine fisheries research.

Jurisdictional Responsibility for Fish and Wildlife

Jurisdictional responsibility for fish and wildlife is vested in the separate states except where the Congress, or the Constitution, has provided otherwise (e.g., migratory birds, endangered species, bald eagles, and all marine mammals unless excepted by waiver of responsibility back to the states). Land-use decisions made by managers of public lands do, nevertheless, have great impact on fish and wildlife resources and so it is imperative that state and federal institutions develop and maintain viable partnerships in formulating and carrying out research and management programs. These institutions must work side by side as cooperators, not as competitors.

Research Responsibilities

Many fish and wildlife problems are complex, and require long periods of study for solution. Some problems can be adequately addressed by one agency acting alone, or even by individual scientists, but many problems cannot. Examples of the former include developing prediction equations that display the impact on fish and wildlife resources of alternative land-management practices in various ecoregions, or the evaluation and development of regional and national ecological classification systems. The research necessary to solve these broad problems essentially precludes the single-agency approach. The basic sciences and wide array of skills, and the levels of funding and manpower required, dictate a cooperative well-coordinated attack. Such undertakings, if they are to be successful, cannot be encumbered by artificial divisions of science, administrative demarcations, political entities, or petty jurisdictional jousting. And the interests and growth of cooperative research groups must never become subservient to motives other than those for which they were originally organized. Different disciplines, when brought to bear upon the complexities, can—through cooperative effort—increase the efficacy of research problem selection and ultimate resolution.

Nevertheless, certain undertakings can better be conducted by one type of institution or agency than by another, provided those institutions or agencies are especially equipped and adapted to the nature of the research they are to pursue. It is evident, for example, that more intensive long-range empirical problems of regional or larger scope should be formulated and pursued by federal and educational institutions. The tasks which must be accommodated are of considerable magnitude, and are vital to the welfare of fish and wildlife resources in this country. The United States, with its research capability and its variety of habitats and species, has the opportunity for gathering and classifying fish and wildlife information that is also of great practical and theoretical interest to a worldwide clientele, especially developing nations.

Some Roles of the Federal Resource Managing Agencies

Resource Management Alternatives

Federal agencies are obligated to understand the consequences of their policy and management decisions as these decisions affect renewable natural resources for which they have responsibility. Research must develop the information necessary to display the impact of various resource management options. Specifically, research is necessary to determine how such major land uses as timber harvesting, road networks, and livestock grazing impact the status of fish and wildlife populations. Other examples include the effects on populations of mining and energy development, vegetation manipulation, growing row crops, fire management, watershed alteration and water diversion, building and highway construction, commercial harvesting, resort development, and recreation and general public use.

Compliance with Federal Law

A major role of federal resource-managing agencies is to identify, coordinate, and fund research required to comply with the multitude of federal laws dealing with natural resources. A need exists, for example, for an extensive centralized information base on relative numbers, distribution, and population status of fish and wildlife by species, and on the amounts, distribution, and availability of their habitats. No such data base is currently available.

Compliance with federal legislation alone is formidable and means that, in many instances, new techniques and approaches must be developed. Cost effectiveness of multiple resource outputs, for example, must also be analyzed and documented, together with the energy efficiency components of particular management actions.

At the present time, no list of wild vertebrates (amphibians, reptiles, birds, mammals, and fishes) or their distribution by habitats exists at the state level. Furthermore, habitat requirements are currently known for only a few of these species. The FS has developed, and is implementing, a plan to obtain quantitative estimates of the supply and demand for more than 3,000 species of amphibians, birds, fishes, mammals, and reptiles that are native or common migrants in the forests and rangeland ecosystems of the U.S. This cooperative effort involves state and federal agencies, and will result in development of the first comprehensive national fish and wildlife data base. These data are useful in national assessments, such as required by the Renewable Resources Planning Act; in land use planning as required by the National Forest Management Act; in state comprehensive fish and wildlife planning as provided by the Federal Aid in Fish and Wildlife Restoration Acts; and for many other purposes that require fish and wildlife information needs at national, regional, state, or sub-state levels.

National and Regional Research Planning Efforts

A vital role that federal resource-managing agencies can play in concert with states and private institutions is the formulation and implementation of research-planning conferences at various levels. An example is the research-planning effort organized in 1976 at the request of the Agricultural Research Policy Advisory Committee. A steering committee was formed, working through the Renewable Natural Resources Foundation, to examine the *conduct* of research. The committee brought together 18 outstanding scientists, administrators, and educators whose recommendations were published in September, 1977, in a document titled "A Review of Forest and Rangeland Research Policies in the United States." To examine the *content* of research, the steering committee organized four regional conferences to identify and prioritize research needs. About 300 delegates attended these working conferences, and identified over 2,000 research problems, concerns, and issues. Subsequently, a 3-day national conference was held to identify research needs of national concern, examine results of the regional meetings, and evaluate research policy.

Finally, seven national task forces met to evaluate results of the planning effort, and identified 51 major areas that need new or increased research attention in the coming decade. Results were published in "National Program of Research for Forests and Associated Rangelands," August, 1978. Those planning efforts dealing with the broad area of fish and wildlife in forest and rangeland environments highlighted three primary research needs: (1) identify and quantify habitat requirements, (2) predict impacts of various land-use practices on habitat and, (3) develop ways to improve forest and range environments for fish and wildlife. Such planning efforts provide valuable guidelines for resource-managing agencies as well as for state and private organizations. They can assist in identifying national, regional, state, and sub-state fish and wildlife research questions; aid in the development of national fish and wildlife programs; and help to assess the level of capability needed to achieve national and regional goals. A similar effort now needs to be initiated to address specific fish and wildlife research needs nationwide. The federal resource-managing agencies should immediately take the lead in developing this planning process, enlisting the help of state and private resource-managing agencies and groups, state colleges and land-grant universities, and private conservation organizations.

Other Roles of the Federal Agencies

Federal agencies can also provide a coordinating function for interagency and intergroup research efforts—particularly those that are essentially funded with federal monies. The interagency research team studying grizzly bears is one example; others include such interagency efforts as continental and regional investigations of migratory birds and anadromous fish, studies of forest birds and endangered plants in Hawaii, and development of animal damage-control techniques. The need continues, however, to develop more effective mechanisms for coordinating public-supported research.

Federal agencies must assume leadership in developing and implementing international treaties, symposia, conventions, and agreements. The FWS has played a vital role in sponsoring international conventions on threatened and endangered species in recent years. In cooperation with other agencies and institutions, FWS has implemented international treaties and agreements dealing with research and management of fish and wildlife, including migratory birds, whooping cranes, polar bear and caribou, Hawaiian monk seals, Atlantic salmon, Puerto Rican parrots, and Great Lakes fishes.

In 1972, the NPS provided the necessary leadership and convened the 2nd World Conference on National Parks. This Conference provided an international forum for exchange of research information on park management, including management of fish and wildlife. Many other examples could be cited.

Multiple resource inventory, assessment, and classification of habitats have been identified as high-priority research needs by numerous agencies and groups, as well as the 1978 "National Research Planning Conference for Forests and Associated Rangelands." In order to effectively conduct inventories of natural resources and assess their status, a classification system must be devised that identifies relatively homogeneous and mappable natural units of land, water, and vegetation. This is necessary so as to enable creation of essential sampling schemes for estimating population parameters of interest. Federal agencies have an important leadership role in the coordination and formulation of these systems, and in conducting broad-scale inventories and assessments. Much of the demand and supply information on resident fish and wildlife species has already been provided by the states, together with data on distribution and population status. Dissemination of research results (technology transfer) to user groups and cooperators—a function that can hardly be overemphasized—constitutes an important role of federal agencies conducting investigations on fish and wildlife and their habitats. These agencies serve many clients at many levels, including policy makers, and acquired knowledge must be transferred quickly and effectively. Delivery is important, but so is proper translation and packaging, since scientific writing has been known to obscure more than it reveals. It is highly desirable, too, for research scientists themselves to become actively involved in applying their findings through demonstration and consultation. Agencies should insure that scientists accomplish and receive adequate recognition for such involvement.

Conclusion

Intelligent and rational management of renewable natural resources in the years immediately ahead will be crucial and enormously difficult. By the year 2,000, a straight-line projection estimates that the human population of the U.S. will increase to 281 million, with 90 percent of that population living or working in cities. Accordingly, the gross national product will increase 240 percent, and demands for timber and timber products 73 percent, for big game hunting 25 percent, freshwater fishing 39 percent, use of water resources 23 percent, and outdoor activities 133 percent. The Environmental Protection Agency forecasts that population and market demands between now and 2,000 will call for the duplication of everything that has ever been built in the history of this country. At stake are the nation's irreplaceable estuaries, wetlands, beaches, floodplains, rivers and lakes, farms and forests, and the habitats of fish and wildlife. Therefore, research must be sharply focused, and the natural resource community must agree, insofar as possible, on national objectives and priorities against which research production can be measured. This is the task, and it must include the coordinated efforts of preservationists, commodity users, bureaucrats, industrialists, scientists, land managers, politicians, and educators.

The usefulness of research and research results must be examined critically on a continuing basis, lest we commit a Type III Error (i.e., collect and provide information for which no one has ever asked or has any use). Research undertakings must assiduously avoid assimilating irrelevant knowledge and mastering inappropriate techniques. Amassing information for its own sake has no place in the complex world of managing renewable natural resources— primarily because we cannot afford this luxury.

Wildlife and fishery research efforts must solve a multitude of extremely difficult sociological, political, economic, industrial, and bio-ecological problems. These efforts must take place at innumerable levels before research can have much hope of applying effective management practices on either public or private lands.

It is time to tighten up the entire research establishment at federal, state, and private levels, and to assume a more active role in developing policy dealing with fish and wildlife. Furthermore, we must become more actively involved in articulating the importance of renewable natural resources, including fish and wildlife, to the strength, health, and safety of the nation, and to its economic and social well-being. Federal agencies have a vital role to play here. The problems are huge, and deserve the finest, most modern, and best-coordinated effort we can possibly conceive, with federal, state, and local governments, individuals, private institutions, foundations, and universities working in concert.

The dissipation of resources and energy by individual agencies or institutions in sporadic, scattered endeavors can produce few advances or little progress. Such endeavors will seldom if ever make any contribution to perpetuating stable, healthy fish and wildlife populations or their environments.

Research groups, irrespective of their organizational or institutional locations, have been subjected to considerable criticism on occasion, much of it thoroughly sincere and deserving serious consideration. It has been argued, for example, that real cooperation among and between scientists, and among and between agencies and institutions, is rarely attainable and, when it does occur, serves only to restrict the freedom and effectiveness of individual scientists. Further, managers frequently state that fish and wildlife research has not been overly productive of useful and important original contributions, nor has it been responsive to their needs. Many researchers agree with the first allegation, but hasten to point out that they have been quite productive in view of historic restrictions imposed on funding and manpower. As to the second criticism, a number of researchers feel that many managers have either not bothered to articulate their needs, or could or would not do so in any event. There is some element of truth in each of these assertions.

Research institutions, in and out of government, vary greatly in size and complexity, in specific aims for which they were created, in organizational structure, and in the quality and quantity of their products. The processes these institutions use to identify and select problems, and document their approach to those problems, often vary greatly, as does the extent to which they affiliate or are isolated from one another. To be effective, however, institutions or agencies must have an adequate source of stable funding, and a logical, rational process for selecting research problems. Furthermore, there must be accountability, and institutions and agencies must produce a meaningful product, avoid stereotyping, retain ample degrees of freedom, be flexible but not limp, and stand for the most thorough and basic development of all subjects for which they are assigned responsibility.

No single agency or institution can possess all of the facts, understand all of the concepts and strategies, grapple successfully with all of the complexities, or bring to bear all of the myriad special scientific capabilities and disciplines necessary to cope with many of the fish and wildlife problems needing research in our modern society. The measure of our success and the advance in our understanding of fish and wildlife problems will be in proportion to the extent we "hang together" as agencies, institutions, and individuals in working toward common goals and objectives. Federal fish and wildlife resource agencies have an important leadership role to play in this scenario, alongside state conservation departments and universities. If we choose to do otherwise, we can be absolutely assured that renewable natural resources—and especially noncommodity resources—will be devoured at the trough of self-interest and apathy while we separately dangle from our individual and provincial "yardarms." To paraphrase Rober Traver in *Anatomy of a Fisherman*, we are probably going this way for the last time; those of us in the renewable natural resource business had better not miss the trip.

The Role of State Agencies in Fish and Wildlife Research

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From the standpoint of state conservation agencies, fish and wildlife research has two primary purposes: (1) to meet informational needs as to the status of species and habitats as a basis for establishing management goals, and (2) to make management goals attainable on the basis of scientific fact. A third purpose, in keeping with university objectives, is to enhance the understanding of fundamental ecological and biological processes. However, there is no single, fixed role for a state agency in fish and wildlife research. There never has been and never will be. State agencies are political institutions and, as such, are individualistic. Roles are shaped over time by different men working in different arenas. In a sense, these agencies are a consequence of evolution. They reflect environments—natural, political, social. They differ in space as environments differ in space, and change over time as environments change over time. Roles reflect the mandates and responsibilities of individual agencies. The common denominator among agencies can only be how reasonable men view environmental responsibility.

The purpose of this paper is to demonstrate that management of fish and wildlife is a shared responsibility of federal and state governmental agencies administered under separate and distinct mandates. Emphasis will be on the role of state conservation departments in fish and wildlife research. We will point out that there are limits to what state conservation departments alone can be expected to accomplish in this research, and further that research programs of state and federal agencies can and should be complimented and supplemented by research programs at academic institutions. Universities, however, need an adequate and sustained base of funding not presently available if they are to employ their research capabilities in the fullest sense.

Responsibility

A basis of responsibility for the consequences of resource utilization and conservation was clearly set forth by Aldo Leopold (1949) in his "Land Ethic," and was recently updated by the timely position paper of Holt and Talbot (1978: 14): "The consequences of resource utilization and implementation of principles of resource conservation are the responsibility of the parties having jurisdiction over the resource, or in the absence of clear jurisdiction, with those having jurisdiction over the users of the resource."

This statement may be viewed as a doctrine of environmental responsibility. Although our emphasis is on the role of state conservation departments in fish and wildlife research and management, we recognize that within the various states there are numerous agencies—state, federal, and local—all of which have individual, mandated responsibilities that significantly affect the use and management of environmental resources. In a broad sense, each citizen and taxpayer shares responsibility for fish, wildlife, and all natural resources.

State ownership doctrine for fish and wildlife is founded on the U.S. Constitution; the 10th Amendement reserves to the states all powers not specifically delegated to the Federal Government. The cornerstone decision of the U.S. Supreme Court was *Geer v. Connecticut* 1896 (Bean 1977: 18–20). However, that decision recognized that powers of the states must not abridge those of the Federal Government conveyed by the U.S. Constitution. Authority for state agencies to manage fish and wildlife is covered by law in all states and is defined in the constitutions of 8 states (Wildlife Management Institute 1977: 1).

Although the relative levels of state, federal and private involvements in the management of fish and wildlife resources may vary by species and by region, much of the resident fish and wildlife within individual states is clearly the responsiblility of the state fish and wildlife department. This responsibility is particularly personified by harvest management—the establishment and enforcement of hunting and fishing regulations.

State conservation departments are mandated by state laws to protect, conserve, increase, and otherwise manage resident and migratory fish and wildlife resources within their respective jursidictions. In some states that mandate extends to nongame, game, common, threatened, and endangered species and to the essential habitats—terrestrial, freshwater, marine, and estuarine—supporting those species. In others, state conservation agencies have no mandate to manage endangered, threatened, nongame, and noncommercial species of fish and wildlife.

As a result of the increased environmental concern that developed in the early 1960s, state agencies are placing increased emphasis on nongame, threatened, and endangered species, on pesticide monitoring, and on pollution. Some of this emphasis is by conservation departments, but in many states part or all such new responsibilities may be supported by other branches of state government. This broadening of responsibility of state agencies over environmental matters reflects broadening of legal responsibility with respect to natural resources.

The legal responsibilities of the U.S. Government with respect to fish and wildlife management also have increased rapidly in recent years. Bean (1977: Preface) states: "Today over 100 treaties, international agreements, federal statutes, executive orders and federal regulations provide a complex array of interrelated and sometimes overlapping requirements."

A recent compilation of federal laws relating to conservation, development of fish and wildlife resources, environmental quality, and oceanography lists 340 titles of laws currently in force (Committee on Merchant Marine and Fisheries 1977). Unquestionably, the role of the Federal Government in resource management and environmental quality is expanding. Unfortunately, the increase in statutory recognition of environmental responsibility is of limited value without provision for funding of research adequate to meet the requirements of resource conservation and management. In effect, we have representation without taxation (e.g., the Marine Mammal Protection Act of 1972).

Increasing federal involvement in "legalistic"fish and wildlife management constitutes what many states believe to be serious encroachment on their traditional roles of responsibility in resource management. Recent problems arising from "blanket" federal protection of alligators and wolves exemplify situations where the responsibility of states to manage has been compromised by federal involvement.

Responsibility for utilization carries a clear obligation for research:

> Timely and accurate scientific information is an essential component . . . investment in such assessment should be related to the intensity of use, the complexity of the problem, and the vulnerability of the system to adverse impact . . . [this] implies both strengthening and some reorientation of research and research procedures. (Holt and Talbot 1977: 17, 18).

The doctrine of environmental responsibility with regard to fish and wildlife research is, to paraphrase from economic theory, support of research by each agency (or institution) according to its mandated responsibility, and on each resource according to its need. Obviously, many agencies would not be in a position to participate directly in all, or even many of the types of necessary research but, on the basis of their responsibilities, would have an obligation to fund or otherwise support research. There is no implied restriction that management agencies should support only management-orientated research.

In most states, work on fish and wildlife is funded primarily with dollars from sales of hunting and fishing licenses and from excise taxes on arms, ammunition, and fishing tackle. The prevailing concept is that state conservation agencies should have the capacity for "problem oriented research within the agency and freedom to contract with outside agencies for basic research."(Wildlife Management Institute 1977: 5). This concept, while not intrinsically restrictive, does not embody the broad doctrine of environmental responsibility, and thus has favored a philosophy of state support primarily for short term, strongly management-oriented research. State agencies are not alone in this respect. The assumption is made by most management agencies that more basic developmental research should be a function of colleges and universities, with little recognition that academic institutions have, at best, a very limited base of sustained support for fish and wildlife studies. There is little recognition by cabinet-level administrators that the states have a responsibility to provide sustained support of fish and wildlife research at colleges and universities; or else the assumption is made that adequate funding for research is readily available "somewhere," or that the answers are already available.

Academic institutions, which have little or no responsibility for direct implementation of resource conservation, are vital instruments for conducting research because of their nature and prescribed function. However, to be effective in research, academic institutions must be funded, and their effectiveness can be maximized only through sustained funding.

Research as a Basis for Management

> Timely and accurate scientific information is an essential component of a conservation program . . . Data collection . . . is itself extremely important, but of equal importance is continual improvement in our understanding of processes in ecosystems and of methods to measure and predict the directions and rates of those processes. Such improved information is necessary to improve and connect management approaches and to adjust them to changing conditions. (Holt and Talbot 1978: 17, 18).

Research, and particularly what may be regarded as basic research, is clearly a basis for fish and wildlife management regardless of the responsible agency or institution.

Ecology informs us of "steady state" or "climax" communities wherein the kinds and numbers of organisms and their relative dominance relationships remain essentially unchanged over extended periods of time. In point of fact, environments are not stable. Over most of the world, the impacts of man are increasingly evident on the landscape; massive environmental change is visible everywhere. Rather than pending stability we see every indication of accelerating rates of change. We see those patterns of ecological diversity and complexity from which stability arises being lost to monotypic agriculture, overgrazed rangelands, pine plantations, channelization, and urban sprawl. For example, the cottontail (*Sylvilagus floridanus*), long Illinois' number one game species, has declined by 70–95 percent throughout much of that state over the last 15–20 years. Preliminary modeling of data on cottontail abundance with land-use statistics for the last 22 years indicates that perhaps 90 percent of the fluctuation in rabbit abundance has been associated with changes in agricultural land use.

A multitude of federal programs, policies, and regulations have far-reaching effects that impact fish and wildlife populations nominally under state jurisdiction, and thus also impact the potential for state conservation departments to conserve and manage those populations. The problems of fish and wildlife in the face of continuing, massive changes in agricultural and nonagricultural land use are grim indeed. A continuing program of research, particularly habitat-related research, is absolutely essential if state and other agencies are to meet the needs of fish and wildlife stressed by changing and unstable environments.

Problems of Administration

It is unreasonable to attempt to solve the problems of research without some clarification of those problems as they relate, in general, to administration. Without some disclaimer, this discussion could (and may still) be interpreted as an indictment of all research, and researchers, of state fish and wildlife departments. Such a conclusion would miss our point: there are many excellent research biologists and investigations supported by state conservation departments, but—in relation to total information needs—quite a few state research programs are now, and likely will remain inadequate.

Decision Making

In a classic paper on the administration of natural resources research, Lyon (1963) used lessons learned from industrial research as a model for research administration applicable to state and federal agencies. Lyon's paper highlighted numerous administrative problems that still limit the potential for fish and wildlife research in some states. For example, top-level administrators are not always professionally trained in a natural resources field or, if so, are not necessarily scientifically oriented. Politically apppointed administrators often have short tenure, thereby reducing the potential for continuity in research programming. Some administrators believe that their function is only management, and do not visualize research as a tool of management. Researchers in state agencies seem always to be in the frustrating position of having to sell research *per se* within their own agencies. Scientific staffs frequently are not consulted prior to administrative decision making that affects research or that is formulated without reference to research findings; then research staffs are often asked to rationalize arbitrary management positions and decisions. Even the best state fish and wildlife administrator is at times almost overwhelmed by the need for immediate answers. Given that need, plus normal budgetary limitations, many administrators fail to see the need for, or cannot in their own minds justify the support of basic, long-term studies.

Research Environment

Failures in decision making typically lead to poor research environments which may take several forms, not the least of which is the inhibition of research by procedures promulgated by non-scientists who simply do not relate to research problems or scientific methods.

Wildlife research has become a highly complex and scientific undertaking utilizing a wide range of scientific specialization—a trend that will increase in the future. It is financially unrealistic for state fish and wildlife departments to fully and adequately equip and staff research programs to undertake the wide range of essential research. One means of combating the above problem is for state fish and wildlife departments to affiliate their research branches with universities—Colorado, Missouri, New York, and Mississippi are fine examples of this type of cooperation. The Illinois Natural History Survey is an example of a state resource research agency that has profited from affiliation with a major university.

Career Opportunity

The lack of career opportunities for research scientists in many state agencies often restricts research. Salary schedules for researchers are typically tied to those of persons in management and are often based on numbers of individuals supervised and size of budget administered. Research by state fish and wildlife departments can never be truly effective until salaries are equivalent to those of federal service or at academic institutions. Since many state fish and wildlife directors are paid little if any more than full academic professors, there is little hope for salary schedules that can provide sufficient career opportunities to facilitate continuity of truly competent research staffs.

The Scope of Current Research

The Wildlife Management Institute (1977: 3) reports that by 1968 all state fish and wildlife agencies were conducting research, most of which was in cooperation with the federal government using Pittman–Robertson (P–R) and Dingell–Johnson (D–J) financing. In 1976, there were 35 state departments doing some type of research on threatened or endangered species. Interstate cooperative research is now relatively common, particularly for those studies no single agency can justify funding—as, for example, research on fish and wildlife diseases, migratory species, and statistical methods. The U.S. Fish and Wildlife Service is an active partner in much of this cooperative research. Almost all states conduct inventories, and attempt some form of modeling, chiefly as a basis for monitoring populations and habitat, and for use in formulating hunting regulations. Freshwater fishes and their habitats are under study in nearly all states, as are saltwater species in coastal states. Limited funds provided under the Anadromous Fish Conservation Act support some state efforts in marine fishery research. Emphasis of state research on pesticides, pollution, and environmental quality is increasing.

The Current Federal Aid Research Report (CFAR P–R 1978, unpublished administrative report, U.S. Fish and Wildlife Service) provides a general, but not complete picture of the scope of wildlife research in state conservation departments. Working from the listing of 743 principal research objectives, we conclude that 89 percent (661) were related primarily to game species, 6 percent (50) to endangered and threatened species, 3 percent (27) to common nongame species, and 1 percent (5) to exotic species other than such introduced game birds as pheasants, gray partridge, and chukar partridge. Interest in endangered and nongame species centered more on birds than on mammals. About 20 percent of the states appeared to be conducting research on endangered and nongame species with P–R funds.

Arbitrary categorization of the 743 principal research objectives as to intradisciplinary effort revealed that 35 percent (257) were primarily related to ecology, population dynamics, taxonomy, and behavior; 25 percent (188) to surveys of abundance, distribution, and harvest; 19 percent (139) to planning and management evaluations; 9 percent (64) to development of techniques; 3 percent (26) to food habits and nutrition; 3 percent (25) to diseases and parasites; 3 percent (22) to publications, mostly directed toward management; 2 percent (16) to physiology; and 1 percent (6) to pesticides and pollution. It was clear the current state research funded under P–R is strongly management oriented.

The advantages of continuity of research funding under P–R are apparent in the CFAR research summary. Projects, mostly of the survey type, go back over 30 years in a few states and over 20 years in several states. Series of uninterrupted census data that span long periods provide a unique basis for evaluating long-term population responses to changing patterns of land use, for developing models to predict future events, and for environmental impact assessments. Loss of P–R funding would be a truly devastating blow to much of the wildlife research currently being conducted by state agencies.

Research Funding

The funding of state fish and wildlife programs long has been derived largely from fishing and hunting license fees and federal excise taxes. State programs of wildlife research have taken primary support from money provided through the P–R Act of 1937. The companion D–J Act of 1950 has also become a major source of funds for state fisheries research.

More recently, funds have become available to the states from such federal legislation as the Commercial Fisheries Research and Development Act (1964), the Anadromous Fish Act (1974), Marine Mammal Protection Act (1972), Endangered Species Act (1973, 1978), Coastal Zone Management Act (1972, and Accelerated Migratory Bird Research Program (1968). These federal acts provide a basis of cooperative funding with the states for research on fish, wildlife, and environmental problems. Today most fish and wildlife research of state agencies is financed by some combination of federal and state monies. Some of this funding is based on short-term grants and contracts to academic institutions.

One consequence of public involvement in matters of environmental policy, beginning in the early 1960s, has been a greatly increased need for information. Broadening environmental attention has caused a shift of focus for the funds programmed for research by state agencies. Not fully appreciated is the fact that environmental research initiated in recent years has often been in direct competition for funding with, and at the expense of research on fish and wildlife. At colleges and universities, in particular, many faculty and students who might otherwise be working on fish and wildlife research are today working on other environmental problems. In large part, this diffusion of research effort results from the lack of readily available funding at academic institutions for fish and wildlife research.

There is a trend evident in the support of fish and wildlife research by state agencies that in part has its roots in current inflationary problems. Research conducted by the Section of Wildlife Research, Illinois Natural History Survey (INHS), under grant from the Illinois Department of Conservation (DOC) using funds available through P–R Project W-66-R, provides an example. The general trend in annual budgets has been upward (Figure 1). However, it was not until budgets were adjusted for inflation that the true picture of support became apparent. Largely because of inflation, the $134,000 budgeted for 1979–80 will only support $52,000 of research based on 1960 dollars. The number of research biologists and the number of projects being investigated under W-66-R have been reduced by half since 1970. Fish and wildlife research done at the INHS also evidences a recent pattern of decline (Figure 2).

There were massive infusions of additional revenues into state budgets in Illinois in the late 1960s and early 1970s (Figure 2). However, wildlife research budgets declined during a period when other state budgets were increasing or holding relatively constant. The downturn in real support of fish and wildlife research does not relate to any decline of P–R funds as those funds show significant increases. The trend in Illinois P–R revenues is necessarily consistent with the national trend. The generally strong state, departmental, and P–R financial resources of recent years suggest a lack of commitment to compensate inflation by proportionate increases in expenditures for wildlife research. Regardless, support for fish and wildlife research in Illinois is not being sustained. We believe that the

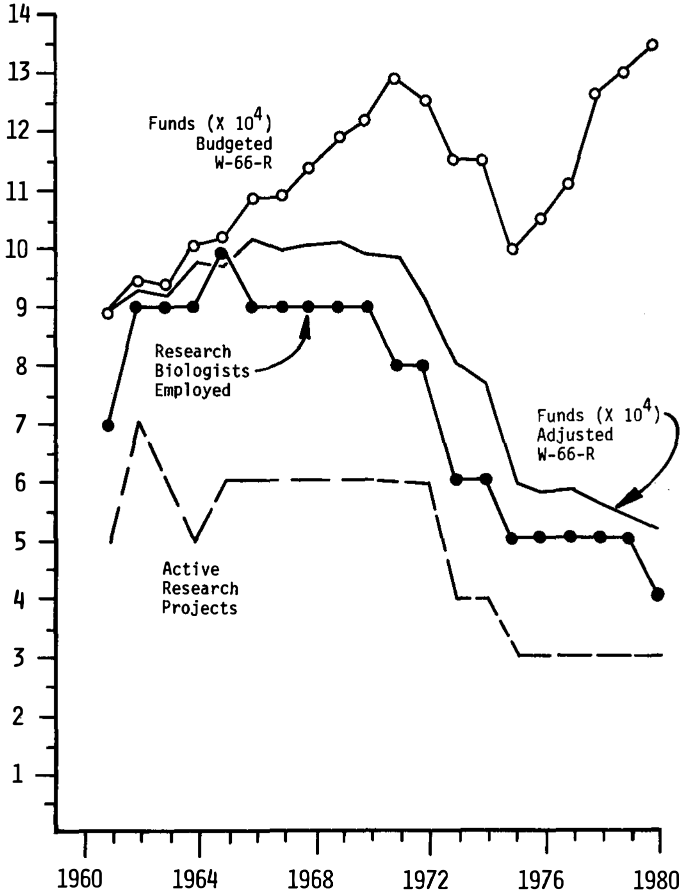

Figure 1. Trends in funds budgeted and adjusted to 1960 dollars, biologists employed, and active projects under Illinois P–R Project W-66-R, 1961–1980.

problem of reduced research support as a consequence of inflation is of national and international proportions. There is a serious question as to whether the public interest is adequately protected as environmental research becomes increasingly financially dependent on prioritized research funded by private industry and by outside units of government.

With little substantive indication that inflation will lessen, and considering national attitudes toward tax reform evidenced by the phenomenon of Howard Jarvis and the passage of Proposition 13 in California, there is little immediate hope for new state revenues that might be directed to fish and wildlife research. Similarly, there is little hope in the near future that any significant additional amount of present state financial resources will be directed to fish and wildlife research. If anything, we can expect to see the support of research by state conservation agencies continue to erode, perhaps at an accelerated rate.

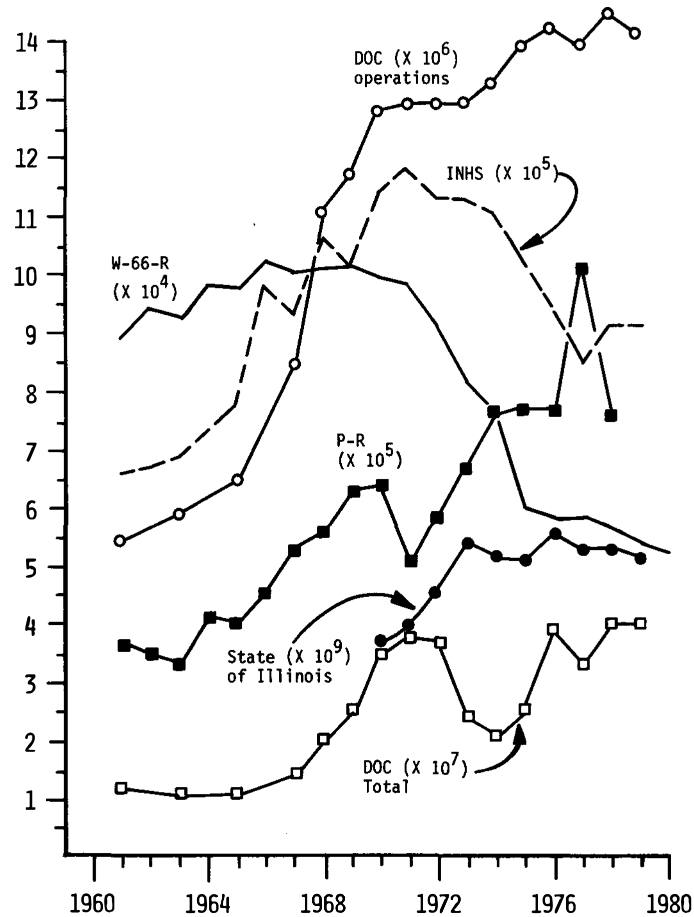

Figure 2. Trends in budgeted funds adjusted to 1960 dollars for the State of Illinois, the total for the Department of Conservation (DOC), for DOC operations, for Federal Aid Project W-66-R, total Federal Aid P–R revenues to Illinois, and the Illinois Natural History Survey for the period 1961-1980.

Clearly, some alternative sources of funding of fish and wildlife research must be found if the growing critical needs of preservation, conservation, and management are to be met. Independent of any need for new and additional fish and wildlife research is a need for new mechanisms of funding simply to maintain present levels of research activity. Prevailing attitudes make it clear that new mechanisms must rest heavily on federal participation. In light of the states' positions of environmental responsibility, it is right that they participate on some basis of matching funds. The overhead cost accounting of universities offers one possible basis of providing matching funds at minimum outlay of state money, and particularly of state conservation department funds.

Discussion

There is no substitute for experience, particularly in garnering ecological insights from observations, interpreting data, and developing models. One has only to look at the past contributions of Leopold, Stoddard, and Errington, and the more contemporary contributions of Bellrose, Komarek, Severinghaus, Riker, Swingle, Hasler, and McFadden, to name but a few, to see the value of long experience. The key to the contributions of these men, beyond their abilities and energies, is that they have been able to spend long careers devoted to one or a relatively few species, habitats, or aspects of biology. Sustained involvement is generally characteristic of leaders in any scientific endeavor, together with freedom to develop new ideas. Our emphasis on long-term involvement does not preclude significant contribution from short-term projects. Many sustained programs are based on a continuity of short term, relatively discrete studies. Although academic research may be accomplished via a series of short-term student projects, the interests of the professor give continuity, provided that there is continuity of funding.

When one appraises contributions of fish and wildlife research to management, the value of long-term involvement becomes obvious. Recently a wildlife administrator from a midwest state commented, in effect: ''Look, the time has passed when we can justify supporting long-term and basic fish and wildlife research projects.'' *In reality, those may be the types of research that we can best afford*! Regardless, the sentiment for reduced support of long-term and basic research by governmental agencies is real; consequently, such research must be accommodated increasingly by some alternate source of funding.

A view commonly expressed at the state level is that a maximum of available funds should be directed to management- (people-) related activities and that every attempt should be made to hold the line on ''less essential'' programs. Almost invariably, research is considered less essential, and its potential contributions to management are largely overlooked. The examples clearly demonstrate that what may appear as ''hold the line funding'' simply does not hold the line, with the result that research programs are not maintained. Failure to sustain research funding can not be attributed to a decline of real P–R revenues (Figure 2). Revenues from P–R, and D–J as well, have shown the ability to sustain real growth during the current period of high inflation. Under prevailing economic conditions, percentage base, excise-tax funding exemplified in P–R clearly is well suited to sustained research funding. Part of the problem is that P–R and D–J funding are inadequate for the tasks at hand.

A second rather prevalent view is that problems of funding fish and wildlife research could be countered effectively if state and federal agencies would individually and collectively reorder their priorities and coordinate their research efforts. Much fish and wildlife research has traditionally been management-oriented. Mission-oriented research is prioritized research. To suggest prioritization as a solution to the current dilemma of funding fish and wildlife research is to ignore prioritization as a cause—or at least a symptom—of more fundamental problems. While prioritization and coordination might help to a limited degree, to consider them as primary solutions to the problem of research funding is unrealistic.

The potential for research prioritization and coordination leading to significant increased availability of funds for fish and wildlife research is relatively small. There is a much greater probability that any savings would be directed elsewhere than to research. Also prioritization can only accentuate the trend to short-term, mission-oriented studies. Prevailing attitudes offer little possibility of increased emphasis for sustained funding of long-term studies of population responses to changing environments, from which management principles naturally flow.

We strongly support the concept that academic institutions should play a greater role in fish and wildlife research. However, we recognize that universities, even in close cooperation with federal and state research programs, cannot be expected to amass and have immediately available the volume of data and analyses necessary to relieve that myriad of environmental pressure-points that inevitably will develop. A primary emphasis of academic research must be on developing broad concepts of ecology and biology, and instilling those concepts into students and into the literature, so that—in time—rational decisions on environmental policy matters can be made in the absence of hard data on individual problems of immediate concern.

Research is almost universally regarded as a primary university function. University scientists are typically expected to "find" the funds necessary to support their research. In many states student-faculty research teams cooperate effectively with state and federal resource managers to solve common problems. However, funding is a weak link. Management agencies do not consider themselves research-funding agencies, and federal research-funding agencies have never been receptive to funding traditional fish and wildlife research, on the grounds that such research is too "applied" and thus should be funded by a management agency. As a result, scientists who could be developing long, productive careers in fish and wildlife research turn their attentions to other problems where continuity of funding is more probable.

Sustained funding of fish and wildlife research at academic institutions would compliment, but not replace, current research by state agencies. It is important for several reasons that fish and wildlife research by state agencies be continued, and preferably expanded, regardless of any additional support for research at colleges and universities. Certain types of research, particularly censuses, population studies, and evaluations can be handled effectively by state fish and wildlife departments. Involvement of state agencies in such studies, particularly when done in coordination with universities, allows state personnel to maintain "contact" with the resource being managed. This contact is extremely important to the growth and development of staff management biologists, and builds bridges of communication with their counterparts in other states, and with department administrators, and scientists in the academic community.

Conclusions

Although increasingly involved in the legalistic aspects of resource management, federal agencies do not have the jurisdictional authority, manpower, or available expertise to cope with local fish and wildlife needs in management or research. In spite of, and often because of, increasing environmental pressures, it is unrealistic to expect state agencies to expand their individual and collective roles in fish and wildlife research. Quite the contrary, hold-the-line attitudes prevalent among state administrators during this period of inflation will most certainly result in reduced research activity at the state-agency level. Federal regulations are increasing the need for fish and wildlife research without providing requisite funding. Although research is a primary mission of today's university, academic research must proceed almost entirely on the basis of grants or special funding. Meeting the research needs inherent in the responsibilities of state and federal agencies can be facilitated by a program of sustained federal funding that involves state matching contributions to support fish and wildlife research at academic institutions.

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Role of Universities in Fish and Wildlife Research

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The Evolution of Fisheries and Wildlife Research in Universities

The role of the university is primarily educational, but much of graduate education takes place by research experience, and a good teacher remains on the forefront of science by virtue of researches into new problems and concepts. The university is a place where fact finding, analysis, and integration merge into unifying principles. Thus, major educational institutions are and must continue to be major research institutions.

Federal agencies, such as the U. S. Biological Survey, conducted some of the earliest applied research in fisheries and wildlife biology and ecology, but universities also became involved very early in applying ecological principles to the study of harvested species. Personnel from state agencies frequently sought help from the dominantly basic university researchers of the day to acquire background data on such facets as foods, reproductive habits, population dynamics, exploitation concepts, survival, census techniques, and habitat selection. Concerned citizens, often those interested in fishing and hunting, expressed interest, exerted pressure, or even financed research by university personnel. These citizens often aided in bringing together personnel from state and federal agencies, and from the university.

Of many classic examples of these early research efforts around the country, a few will suffice. Cooperative funding arranged by J. N. ''Ding'' Darling, the Iowa Fish and Game Commission, and Iowa State College resulted in the hiring of Paul L. Errington in 1932 to conduct research on the bobwhite (*Colinus virginianus*) and other game species. In addition to significant studies on bobwhite, great-horned owls (*Bubo virgianianus*) and ring-necked pheasants (*Phasianus colchicus*) that yielded far-reaching implications on predation and population regulation, Errington initiated studies of muskrats (*Ondatra zibethicus*) that spanned 25 years and subjects ranging from diseases to population regulation mechanisms (Errington 1963). Much of this research ultimately was supported by the Iowa Agricultural Experiment Station. This cooperative effort also led, in 1935, to the establishment of the Cooperative Wildlife Research Unit Program—mostly through the interests of Darling.

At the University of Minnesota, the pioneering work of Ralph T. King on cyclic behavior of ruffed grouse (*Bonasa umbellus*) was initiated by a cooperative venture between the Sporting Arms and Ammunition Manufacturers' Institute and the University, and was prompted by two other pioneers in the field, Herbert L. Stoddard and Aldo Leopold. King's population studies, inaugurated in 1932, have been followed to date with few interruptions by such workers as Gustav A. Swanson, William H. Marshall, and Gordon W. Gullion. Financial support for most of this work also was eventually assumed by the State Agricultural Experiment Station, with the Ruffed Grouse Society playing a significant role as well (Hodson 1976).

Several examples also exist in fisheries. Long term studies of stocking rates by Homer Swingle at Auburn University, and of growth rates by Kenneth D. Carlander at Iowa State University, are both notable efforts dominantly supported by state funds.

The development of the Cooperative Research Unit Program was a significant step in the identification of research needs and in the funding of graduate research programs at many universities. Program funding was truly cooperative, with the Unit Leader an employee of the U. S. Fish and Wildlife Service, project funds mostly from the state natural resource agency, and facilities and some staff provided by the university. There are now 21 Wildlife, 26 Fisheries, and 3 Fisheries and Wildlife Cooperative Research Units. Not only have these Units served in educating a large number of the current resource managers and university faculty of North America, but they have also produced a wealth of research data and now act as focal points for federal contracts for research. Cooperative Park Service units at several locations operate on a smaller scale but with a similar pattern.

Other cooperative programs between state agencies and universities have been successful, continuing ventures in a number of states, and the mutual benefits have been many. Some of these programs have involved Pittman–Robertson and Dingell–Johnson funding on approved state agency projects that are directed by either agency or university personnel, sometimes both cooperatively. These programs have added greatly to the breadth of research for both groups and, because state university salaries can be used to match such federal funds, state agencies can direct their efforts to needed habitat research rather that return unspent monies to Federal Aid. States not involved in such programs need to seriously consider the advantages of this system in redirecting ongoing programs as well as initiating new ones.

In some areas of natural resource research, the concept of agency–university interaction has reached a still more sophisticated level. Forestry schools in two sections of the country have formed unique consortia to address large, complex and interdisciplinary objectives that could not be met in any other way. Funds for this research are provided by the U. S. Forest Service through its respective regional experiment stations, and certain work units of those stations are part of the consortia. Wildlife research is prominent in this program. Similar consortia of wildlife agencies in any major geographic region could minimize duplications and produce blocks of funds to tackle major resource problems of an interdisciplinary nature.

An important development in some states has been the assumption of farm- and forest-related research programs by land grant universities, through Agricultural Experiment Stations. In some states, funding has been minimal, but the Station acts as an agent for grants. Another important contribution of the USDA Science and Education Administration is the information retrieval service provided by the Cooperative Research group. Cooperative Research also assists researchers and administrators in coordinating and unifying efforts toward some research goal through on-site reviews. In other areas of the country, major funds have been dedicated to state fish and wildlife programs. Cooperative Agricultural Experiment Station projects such as the S-83 Aquaculture project of the Southern Region have been effective in consolidating and coordinating efforts over a large geographic area. Bird depredations research in the northeast, where there has also been a cooperative research effort by experiment stations of that region, is another example. Little federal funding has been used in most areas, but the interest by the United States Department of Agriculture in all wildlife work has increased markedly—in relation to both forest and farm wildlife. Hopefully, fisheries and widlife projects will gain high priority as natural resources become a recognized and integrated component of all land use. Additionally, the U. S. Department of Interior needs to examine funding approaches comparable to those used by the U. S. Department of Agriculture and the U. S. Department of Commerce through various land grant, sea grant, and competitive grant programs.

International interests are becoming more and more important to wildlife and fisheries departments in universities. These funds have enabled such universities as Auburn, Rhode Island, Washington, and Oregon State to develop research facilities and programs on campus. International programs through the U. S. Agency for International Development and other agencies have built the physical facilities at Auburn University, and put Auburn in a position to become a major organization in freshwater fisheries and aquaculture. The protection and management of endangered species is another important responsibility of the U. S. Fish and Wildlife Service that has resulted in cooperative research programs overseas. In addition, research and development technology can be transported back to the state because, many times, the effort involves organisms or problems of wide geographic and cultural interest.

The development of major fish and wildlife research centers by the U. S. Fish and Wildlife Service has not only greatly expanded the national research effort but has led to many cooperative research programs with universities throughout the U. S. as well as in foreign lands. Recent Fish and Wildlife Service programs in wildlife diseases and endangered species have also led to cooperative research programs at academic institutions in the U. S.

What Universities are Doing Today

From an early history of fact-finding and observational field research, most fisheries and wildlife programs today are geared to more sophisticated, experimental laboratory research, as well as field study that involves sound theoretical approaches. There has been a gradual transition from the study of life histories of important fish and game animals and the development of census techniques to the development of management strategies, conceptual models applying theoretical ecology in a management framework, systems modeling, and planning for all fish and wildlife species—game and nongame. There also has been a transition from studying and managing species to working with communities as interpreted by current ecosystem concepts. These diverse research roles and directions are coupled with graduate and sometimes undergraduate education to produce up-to-date professionals as well as useful research findings and philosophies.

In general, research activities in universities differ from those in state or federal agencies by being more fundamental as opposed to applied, experimental and conceptual as opposed to observational, and interdisciplinary as opposed to disciplinary. These are vital approaches and goals in an applied science where practice too often precedes experimental evidence. Moreover, such approaches help to set research priorities for improving management techniques. State agencies rarely have funds to meet their management and regulatory functions, much less develop fundamental research programs. Universities can and should fill this vital role.

Agencies today often require data to satisfy regulatory needs or justify harvest or management procedures. Often these are short-term projects meeting emergency situations, and the accumulation of such baseline data may not meet the usual criteria of originality essential to most graduate research programs. A cooperative view of research by funding agencies is, therefore, essential if universities are to have the freedom to approach projects from different viewpoints and analyze data in different ways to meet academic as well as agency goals. Where this freedom is lacking, simple data acquisition becomes a routine service, usually outside the university's role. Private consulting firms should be able to fill these needs.

To meet the future needs of resource managers, some research group must be involved in long-term, directed research efforts that provide the data base for sound management objectives. This must involve more theoretical and conceptual approaches because, in recent years, some of the most significant management concepts have come from basic researchers whose primary interest is not conservation, but who have the insights to broadly apply basic principles. This approach is both a tribute and a caution, because contemporary research goals may be penetrating and innovative in spite of the necessity to meet short-term goals. Nevertheless, "we're all in this together," and must dedicate ourselves to the idea that research must be ongoing at several levels, satisfying short-term and long-term needs, and looking at management concepts, socio-economic considerations, and philosophies as well as techniques and policies.

Current contract procedures of many state and federal agencies impact on how university faculties do their research. But once goals are established, they should be recognized by both parties. In recent years, university personnel have been less mobile than have personnel in sponsoring agencies. Personnel changes among agencies often create new research interests, but unprogrammed changes may shorten research continuity and minimize potential accomplishments.

While recognizing what university faculties have been doing well, it is also obvious that they have made mistakes in research priorities and design and, in some cases, are still making mistakes. Agency personnel suffer similar hazards of confusion over research priorities and their effective accomplishment. Duplication of effort, using the same approaches on the same animal but in a different area, is all too common. These efforts may provide educational experiences for graduate students, but they add less to the total data base, channel students away from creative thinking, and divert funds from priority projects. Some of these directions and duplications are a product of lack of funding. The major project may be unobtainable, so the goals are lowered to achieve goals within funding limits. Though not an excuse for shortsightedness or for lack of innovative approaches, limited funding is an impediment to ideal research strategies.

Advantages of the University for Research

Human Resources

Most universities include research as one of their missions and, as a result, have a faculty with interests, direction, stability, and freedom to do long- or short-term research. Very often the weak component in the system is research program funding on a sustained, reliable basis; faculty time is relatively inexpensive—even on contracts. Moreover, the faculty member usually is in a position to call upon expertise from various disciplines at little or no cost, and can form interdisciplinary teams. In integrative sciences, the input from fields such as psychology, sociology, economics, political science, and law may be as vital as the input from chemistry, physics, and other basic sciences.

Most faculty members develop a personal research project with a design that provides continuity, integration and regular reporting. Much of the field or laboratory work may result from shorter-term student projects terminating in theses—an almost assured product, usually well-edited, and more often published than similar products from state or federal agencies.

Students form one of the greatest strengths of the university. They bring to projects a vested interest resulting in imagination, eagerness, and hard work that should enhance the entire program as well as form productive information packages from their projects. In today's employment market, the real need is not to increase the number of students but to provide quality students experienced with well-planned and well-conducted projects. These projects are often money-limited, and their scope, sophistication, and output are affected.

The combination of faculty-student teams allows building a long-term data base that can be stored, added to, and retrieved. This team can work closely with agency personnel toward mutual goals, and the student gains relevant experience with modern approaches while making contacts with agency personnel that better prepare him or her for employment.

Facilities

Few independent or governmental research labs can afford to duplicate the research facilities that form an integral component of every major university. Among the most important of these are (1) libraries, including reference facilities, computer-based sorting, indexing and abstracting services; (2) statistical advice and services, including computer-based programs for analysis; (3) computer facilities, that allow data storage and retrieval, statistical and graphic analyses, and direct recording and analysis of voluminous and complex data sets; (4)

museums, including specimen collections for identification, supporting life history data such as call or song recordings, facilities for specimen preparation, taxonomic analysis, and comparative study; (5) sophisticated equipment often not feasible for smaller research units, and shops to build specialized items; (6) audio-visual services, including drafting, photography, display materials, and slides; and (7) specialized research labs aided by advisory services on the uses of special materials such as radioisotopes, and x-ray analyses.

Administrative Systems

For grants, contracts and formula funding, universities provide purchasing services, accounting and cost-analysis facilities, carry-over advantages, and other specific procedures that reduce the workload for funding bodies and facilitate dedication of effort to the intended research. Although often a source of concern, overhead rates at universities typically are much lower than in industry.

Extension Programs

Combined with gathering research data is the need to reach lay audiences with information that raises the level of social involvement and promotes the intelligent understanding of resource problems and management techniques (Kevern 1973). Cooperative Extension Services of land-grant institutions have set the stage for such endeavors in fisheries and wildlife, and such programs are increasingly important components of university programs, Sea Grant programs, and state and federal agencies. They are vital to research because they offer a feedback mechanism identifying current needs that demand short- or long-term research efforts. Moreover, they sometimes provide in-service training programs for agency personnel.

Additionally, extension personnel form a liaison between differing or even conflicting ideas encountered between wildlife and fishery professionals and clientele groups—a role of increasing importance that must be dealt with objectively if we are to gain respect and develop sound programs. Concurrently, management strategies gain acceptance as the public learns of the reasons behind regulations or programs.

Present Sources and Problems of Funding

Any university program or department could list a great array of supporting agencies or organizations that have provided funds via grants and contracts (see examples in Table 1). However, the diversity often is a product of small size of individual grants. Many are of short duration, directed toward specific information packages, and lacking in flexibility. Projects funded on a short-term basis require more time in the preparation of reports and new proposals, time that might be spent on research design, analyses, and the preparation of publications.

Few sources provide even an opportunity for continuity and long-term research, or basic approaches to resource management problems. A few wildlife and fisheries projects funded by Agricultural Experiment Stations are the exceptions. In most cases, programmatic approaches to research are a product of many short-term projects or contracts—reducing research achievements.

Table 1. Examples of typical funding sources.

Private	- a) Endowed research programs (McGraw, Tall Timbers, Welder). b) Foundations (World Wildlife, Kleberg, Ford, Rockefeller, North American Wildlife). c) National societies and organizations (Audubon, National Wildlife Federation, Wildlife Management Institute, Ducks Unlimited).
Business	- Power and utility companies, consulting firms, manufacturing companies.
Civic	- Park and recreation centers.
State	- Fishery and wildlife agencies, departments of natural resources, conservation departments, highway departments, universities.
Regional	- Great Lakes Fisheries Commission, Tennessee Valley Authority, Mississippi River Commission.
State-Federal	- Cooperative Research Units (University-State Agency-U.S. Fish and Wildlife Service).
Federal	- U.S. Department of Agriculture—formula funding to land-grant universities (Hatch, McIntire-Stennis). Sea Grant (NOAA, U.S. Department of Commerce). Conservation agencies—Fish and Wildlife Service, Soil Conservation Service, National Park Service, Forest Service. Granting Agencies—National Science Foundation, National Institutes of Health, Environmental Protection Agency, National Oceanic and Atmospheric Administration.
International	World Wildlife Fund, Peace Corps, Smithsonian, International Union for Conservation of Nature, United Nations Food and Agriculture Organization, Agency for International Development.

Some federal granting agencies and research-proposal review panels do not seem supportive of fishery and wildlife research because they consider the work too "applied," or because they assume there are other sources of support for such work. State and federal fish and wildlife agencies may think university research too basic and too far from reality. A median view is essential since it is the university atmosphere that fosters discovery and sets the stage for application of basic principles to resource problems.

While grant monies (Table 1) are essential to many specialty types of research, the greatest single need to stimulate university research in fisheries and wildlife is the provision of recurring state or federal funding for long-term, fundamental research directed toward fish and wildlife resource management. Not only will this allow development of more fundamental approaches, it will permit more sophisticated research by students—further preparing them for more demanding roles in agencies. Mechanisms for directing and administering such funding are already in existence in land-grant institutions.

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Enabling Mechanisms for the Support of Fish and Wildlife Research at Academic Institutions

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In 1975, 95 million people, or nearly half of all Americans, participated in some type of wildlife- or fishery-related activity. Our profession indeed serves a large clientele. Our responsibility however, does not stop with that client group alone. The fish and wildlife community shares, with other natural resources professions, the responsibility for maintaining the integrity of the ecosystem upon which all life depends. Thus, our natural resource base serves all people—young and old, rich and poor, male and female, in all ways —esthetically, economically, recreationally, and biologically.

As professionals we can look with pride on a rather substantive record of accomplishments on behalf of this nation's natural resources. We can also identify, with chagrin, many inadequacies. The future will bring even more stressful challenges than did the past. User demands for fish and wildlife resources will increase because of a larger and more affluent human population with more leisure time, while the resource base will be subjected to greater environmental impacts stemming from pollution, surface mining, production agriculture, forestry, waterflow alterations, saltwater intrusions, and urban development. Understand that we are addressing not only the negative impacts on the esthetic, recreational, and economic components of fish and wildlife, but also those affecting the functional quality of the ecosystem per se. It is not a time for complacency or games. Rather it is a time for fish and wildlife professionals to pool and coordinate their efforts in addressing the urgent problems at hand, problems that are—literally speaking—as "big as all outdoors."

In the 17th Century, the philospher Francis Bacon astutely stated: "We cannot command nature except by obeying her." A prerequisite to comfortable obedience is understanding; a prerequisite to understanding is knowledge gained through research. It is our purpose today to identify how we, as professionals, may best chart a path to enhance our research accomplishments in fishery and wildlife sciences.

Problems, Challenges, and Outlook

The scope of problems and challenges in fish and wildlife research, upon which management is dependent, far exceeds the capabilities of our resource agencies and institutions. The priority need, therefore, is to insure the effective application of existing agency and institutional resources. Within this structural framework, academic institutions, which have a charged research mission, occupy an unusual position. Although, as educational institutions, they have a complement of fish and wildlife faculty in place, this pool of scientific expertise is generally underutilized because of the traditional lack of support funds available to academic institutions for the conduct of fish and wildlife research. An adequate and sustained level of funding is needed to bring the full capabilities of academic institutions to bear on this nation's fish and wildlife resources problems.

Research Support at Academic Institutions

We have identified academic institutions as an underutilized resource in fish and wildlife research programming. Yet these institutions, despite inadequate funding, are strongly involved in research pursuits, so it is appropriate to examine the major sources of funds presently available to them to support fish and wildlife research.

State Revenues

Fish and wildlife programs at academic institutions receive limited support from monies allocated by their respective state legislatures. However, the competition for these funds within universities is great because state monies must also support the total array of educational and research programs for which universities have charged responsibilities.

Federal Appropriations

State land-grant colleges and universities are eligible to receive funds for the support of fish and wildlife research through the Hatch Act (1887) and the McIntire–Stennis Cooperative Forestry Research Act (1962). These two programs are administered by the Science and Education Administration/Cooperative Research, U.S. Department of Agriculture. However, the Hatch and McIntire-Stennis Acts were designed principally to support agricultural and forestry research, respectively, and consequently are not mainline sources of funds for fish and wildlife research. Furthermore, appropriations for these Acts are currently inadequate for priority research demands in agriculture and forestry, and cannot be expected to support the additional spectrum of research needs in fisheries and wildlife.

Some federal funds for marine fisheries research are available to academic institutions under the auspicies of the National Sea Grant College and Program

Act (1960). This Act, now administered by the National Oceanic and Atmospheric Administration, U.S. Department of Commerce, is directed toward the development and management of all marine resources, of which fisheries research is but a single facet. Under this Act, funding is principally awarded to institutions, designated Sea Grant Colleges, which have established broad bases of competence in marine affairs; mechanisms also exist for limited support of marine activities at other institutions and agencies.

Federal "Pass-through" Dollars

In a few states, some funds appropriated to state fish and wildlife agencies under the auspices of the Pittman–Robertson Federal Aid in Wildlife Restoration Act (1937) and the Dingell–Johnson Federal Aid in Fish Restoration Act (1950) are made available by the agencies for the support of specific research projects at academic institutions. Both Acts are administered cooperatively by the Fish and Wildlife Service, U.S. Department of Interior. On the whole, such funding contracts have never been substantial, and can be expected to diminish further because of the shifting allocation of Pittman–Robertson and Dingell–Johnson dollars to support the increasing array of resource management problems with which state agencies must cope.

Grant Funds

External grants, generated on a competitive basis from federal, state, or private agencies, have contributed substantially to the support of fish and wildlife research programs at academic institutions in recent years. Noteworthy in this respect are federal funds generated through the Endangered Species Act (1973) and the Commercial Fisheries Research and Development Act (1964). External funding, however, has significant shortcomings. First, the temporary or short-term nature of special grants does not provide for the stability and continuity of funding needed to undertake the substantive or long-term research that is essential in resource management. Second, the authority under which the grant monies are appropriated often severely constrains the type of research undertaken; i.e., monies, more often than not, are earmarked for specific, immediate problem-solving. Third, competent professionals in the same and different agencies and institutions are often expending valuable time and energy competing for the *same* dollars. Fourth, institutions without a continuing base of research support often cannot keep personnel and facilities sufficiently in place to be competitive for grants—or even effectively utilize special grants awarded to them.

The profile for sustained funding of fish and wildlife research shapes up somewhat as follows. Those federal agencies involved in fish and wildlife research and management have federally appropriated monies to support their programs. State fish and wildlife agencies have state appropriations (principally license revenues), and also qualify under formula-funding for Federal Aid monies mandated under the Pittman–Robertson and Dingell–Johnson Acts. However, academic institutions have no continuing federal funds and only a low level of continuing state support (or none at all) designated specifically for fish and wildlife research. Although some academic institutions are eligible for Hatch, McIntire-Stennis, and

Sea Grant funds, these appropriations principally serve agricultural, forestry and marine resources research needs, and are inadequate even for that purpose.

Academic institutions, then, are the only major public-service institutions with a mandated research mission that do not have a sustained funding base that can be directed to fish- and wildlife-related research. This really means that we have a large pool of scientific talent and facilities in our nation's universities that is not being deployed to solve critical current and emerging problems impacting our fish and wildlife resources. In this light, we propose an enabling mechanism that will provide adequate, sustained funding for the support of fish and wildlife research at academic institutions.

The Enabling Mechanism

The enactment of a federally-funded FISH AND WILDLIFE RESOURCES RESEARCH ACT is proposed. The purpose of this ACT is to provide an adequate, sustained level of funding to strengthen *existing*, but currently under-funded fish and wildlife research programs at academic institutions in the United States. The intent of this ACT is *not* to provide dollars for either building or supporting undergraduate academic programs in fish and wildlife sciences. Rather, funds available through this ACT would be targeted specifically for the conduct of both broadened and in-depth research, basic and applied, by academic faculty and graduate students. Implementation of the ACT would facilitate the maximum use of talents already available and, thereby, increase both the quantity and quality of research productivity.

Major funding features of the ACT shall include: apportionment of monies by formula; allocation of monies through competitive grants; and provision of non-federal matching funds by recipient academic institutions. Under this ACT, formula- and competitive-grant funding shall be available to the academic institution within each state that contains the most viable fish and wildlife programs as determined by critical mass of faculty, educational curriculum, and history of performance. In states with two or more eligible institutions, the eligible institutions(s) shall be designated by the Governor, or by a special review committee. Some proportionate amount of the total competitive grant allocation shall also be made available, on a project basis, to non-designated academic institutions.

It is proposed that the ACT be administered by the Department of Interior, under guidance of an external scientific advisory committee. Inherent in administration of the ACT will be provisions for evaluation and coordination of the total spectrum of fish and wildlife research conducted by all participating institutions, as well as review of individual research projects. The ACT itself shall be subject to review by Congress at intervals of 10 years.

Existing Federal Programs

In formulating the proposed FISH AND WILDLIFE RESOURCES RESEARCH ACT, several existing federal programs were reviewed as to their potential value as alternative mechanisms. Among these were the McIntire–Stennis Cooperative Forestry Research Act, the Pittman–Robertson and Dingell–Johnson Acts, and the Land and Water Conservation Act. The amendment of one or more of these Acts to include additional funds for fish and wildlife research at academic institutions would have a major advantage in that the legislative mechanism is already in place, and time-tested. However, the appropriations for these Acts already are inadequate to fully support existing programs; broadening the existing laws would merely promote interagency competition instead of interagency cooperation. Then, too, amendments to authorize additional funding for all but the McIntire–Stennis Act would require modifications in special taxation mechanisms, which history indicates would be most difficult to achieve.

Consideration was given also to the expansion or modification of the Cooperative Fishery and Wildlife Research Unit program, which has been implemented in 29 states. Here again, we have a time-tested mechanism in place. Historically, funding of Unit programs has been woefully inadequate. Further, the Unit program would have to be restructured to accommodate the programs and missions of fish and wildlife research at academic institutions. This alteration we deem undesirable because it would necessitate the dismantling of a small but uniquely viable research vehicle whose trademark has been interagency cooperation (state, federal, university, and private). Finally, we firmly believe that funds available through the proposed FISH AND WILDLIFE RESOURCES RESEARCH ACT would indirectly strengthen existing Unit programs.

The Proposed Act, In Review

A federally funded FISH AND WILDLIFE RESOURCES RESEARCH ACT is proposed as a mechanism to provide an adequate and sustained level of funding for strengthening and broadening fish and wildlife research programs at academic institutions. Authorization of this funding mechanism would enable universities, with their large array of scientific disciplines, to become major contributors, along with federal, state and private agencies, in solving complex fish and wildlife research and management problems in the United States. Specifically, the ACT would enable universities to: (1) develop unique types of data bases necessary for decision-making processes in fish and wildlife management; (2) collect information needed to support accelerated and expanded programs in technology transfer (i.e., technical support for newly mandated extension programs in natural resources); (3) accrue research information required for fulfilling congressionally mandated assessment and management programs in renewable natural resources (e.g., Forest and Rangelands Resources Planning Act, Resources Conservation Act, Fishery Management Plans); (4) participate in research programming at interstate, regional, and national levels; (5) improve the scope and quality of graduate training programs (through accelerated research programs); and (6) enhance the research productivity of existing academic faculties in fishery and wildlife sciences.

The proposed FISH AND WILDLIFE RESOURCES RESEARCH ACT would provide a vehicle that would better enable the fishery and wildlife community to fulfill its charged responsibilities to the nation's natural resources. Again, we wish to emphasize that the intent of the proposed ACT is not one of developmental program expansion. Its purpose is to provide support for academic research programs in fishery and wildlife sciences that are already in place. We invite your encouragement and support of this ACT, now and in the days ahead.

Acknowledgments

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Concluding Remarks

John S. Gottschalk

After having been given what might almost be called a surfeit of information about our subject, "Wildlife and Fisheries Research Needs," a deliberate and comprehensive summary by me of these carefully prepared and professionally presented papers would, I fear, give us all a severe case of intellectual indigestion. However, it will not suffice in the way of summation just to say that wildlife and fisheries research programs in North America are in trouble. As a Hoosier sage of a generation ago said so pointedly, "Jest stand'n fer what's right don't help much. The thing to do is t'git out and hustle fer it!"

The analyses of the status and problems of our fish and wildlife research efforts that you have just heard, nevertheless may be summed up and characterized as but one set of the problems of a society afflicted by continuing population growth and dwindling resources, especially land and water. It has been amply demonstrated by these papers that our problems of sustaining the production of fish and wildlife in future years will grow at something approaching a geometric rate. It is not a simple question of learning more about our living resources, though with the broadening consciousness of the ecological web that in itself constitutes a tremendous challenge. We must learn how to "make more with less"—to make fewer acres of land or water sustain the numbers and varieties of fish and wildlife essential for the food and recreational needs of future generations.

The official overseers of this nation's fish and wildlife resources include federal and state natural resources agencies, universities, and private conservation organizations, each of which plays a different but vital role in balancing the scale of progressive resource management. But progressive management requires pace-setting research, and research requires dollars. Though research dollars for anyone are seemingly always in short supply, the problem of inadequate funding of fish and wildlife research at our universities, as was documented here today, is an issue to be reckoned with.

Those of us in the profession, as well as our friends and supporters outside the profession, are indeed going to have "t'git out and hustle." We are in a democratic society where the squeaking wheel syndrome is a fact of life. We are, of necessity, under a compulsion to identify and, where possible, to quantify what benefits society is giving up by the slippage in fish and wildlife research. We must find ways of translating the social penalties into terms the public—and the public's representatives—can understand and relate to other competing demands. The translation must carry the urgency of the original text—that without more and assured financing, the public will be the loser.

It will be neither easy nor quick to accomplish the sequential steps in this scenario. We professionals will have to work together to develop the factual basis for our concerns, and work with the national conservation organizations to enlist their support in making our problems a cause for national concern. We will then have to engage the attention of our law-makers to establish the framework for the financial support that is essential. It will not be easy, but it can be done.

Northern Resource Developments: Fish and Wildlife Implications

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Hydroelectric Developments in Northern Québec

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Introduction

Québec has a relatively long history of hydroelectric developments. In 1929, the St. Lawrence was harnessed for the production of electricity, and since then the southern regions of Québec have witnessed generations of hydroelectric plants. Projects on the St. Lawrence, and Ottawa rivers were developed for domestic use, while those on their tributaries were developed essentially for the pulp and paper, and aluminum industries.

In 1961, the electric industry was nationalized and a single crown corporation, Hydro-Québec was founded. In the last two decades, many large watersheds were developed in Québec and neighboring Labrador. They included the Churchill Falls development and the complex of generating stations on the Outardes and Manicouagan rivers. The strategy was to begin a new project as the current one was nearing completion, assuming that growing energy demands would always outstrip the possible production. Within this framework, it was logical to phase in the development of the hydroelectric resources of northwestern Québec (James Bay project) in the early seventies. However, two concurrent events associated with the start of the James Bay project were to have a major influence on all future developments. The first event was the universal awakening to environmental concerns while the second was the political fanfare with which the project was announced.

A brief summary of the events of the time will help to set the historical context. In the summer of 1970, the Premier of Québec went on an international tour, seeking funds for the James Bay project. Meanwhile, Hydro-Québec was conducting feasibility studies on the southern portion of the development. In the spring of 1971, two reports prepared by consulting firms established the feasibility of developing both the southern and northern sections of the James Bay Territory. On

April 29, 1971, the premier made the James Bay project public in a dramatic fashion and literally to the sounds of trumpets.

In July 1971, the Quebec National Assembly passed Bill 50. The law created the James Bay Development Corporation (Société de Développement de la Baie James - SDBJ). The newly formed crown corporation was given the mandate to develop all the resources of the 133,377 square mile (345,446 sq km) James Bay Territory. The vanguard pursuit of the SDBJ was the development of hydroelectric resources, and soon a daughter corporation, the James Bay Energy Corporation (Société d'Energie de la Baie James - SEBJ) was created specifically to deal with hydroelectric developments.

By September 1971, acute public concerns about environmental matters justified the creation of a Federal-Provincial commission to perform an environmen-

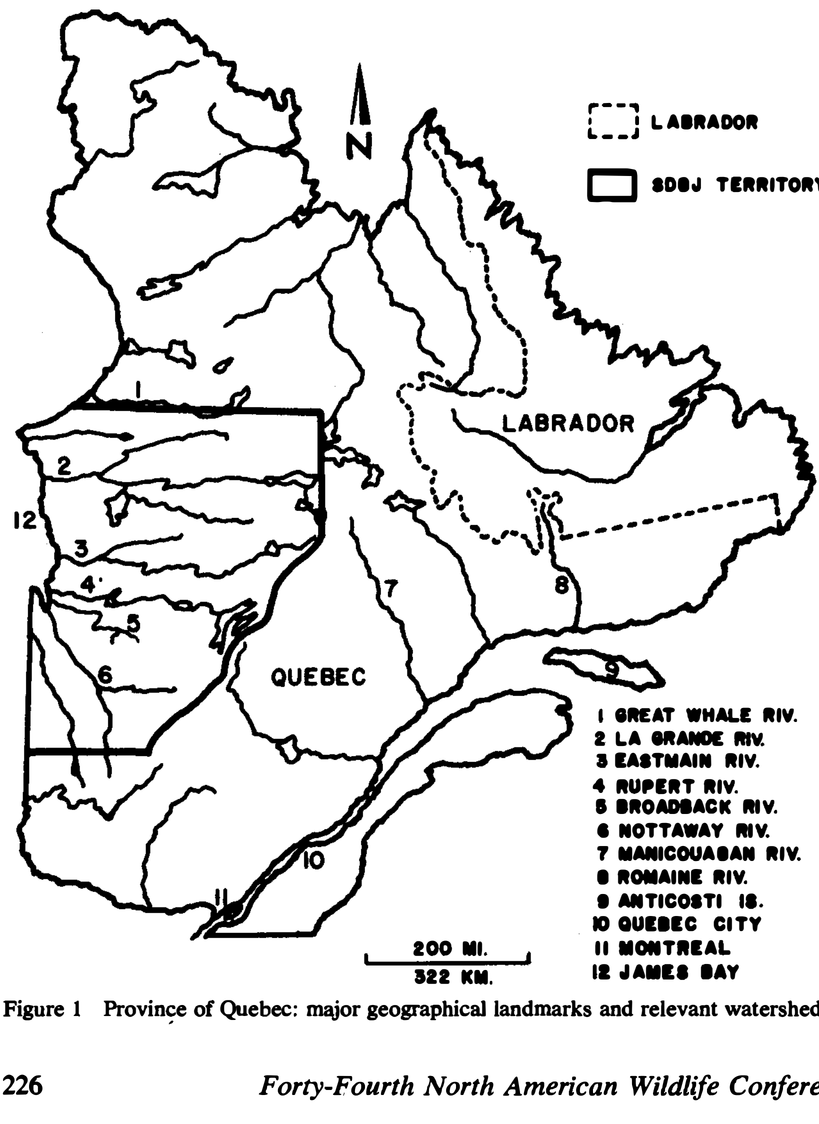

Figure 1 Province of Quebec: major geographical landmarks and relevant watersheds.

tal assessment. Their mandate included determining which portion (south or north) of the James Bay Territory would be least affected by a hydroelectric development. A northern development meant the derivation of the Eastmain, Opinaca and Caniapiscau rivers into the La Grande, with four powerhouses built on the latter. A southern development (NBR) included the harnessing of the Rupert River, augmented by derivations from the Nottaway and Broadback rivers. The commission was given $30,000 and three months, to report their findings. The study pointed to the paucity of data and that a northern complex would likely cause less impact on the environment than a development in the richer (population, timber, soils) southern section.

Thus the more northern La Grande complex was to be the precursor, where eventually everyone would learn how to cope with the realities of northern developments in a period of universal environmental concerns. The more southern NBR project was temporarily shelved. While the turmoil over James Bay came to a peak, Hydro-Québec began investigating the possibilities of harnessing more northern watersheds. At present two projects are under intensive study. The first one is the development of the Great Whale complex (Figure 1), in the Lower Hudson Bay area and the other project is the development of the Romaine River watershed (Figure 1), on the North shore of the Gulf of St. Lawrence. There is no reason to doubt that eventually most northern watersheds will be included in the massive hydroelectric network.

The northern hydroelectric option provided more socioeconomic benefits than the thermal or nuclear options which had been considered in 1970 (Bourassa 1973). It involved the construction of large dams, reservoirs, powerhouses and infrastructures; all of which represented great potential for the creation of jobs.

A new and important consideration in the northern hydroelectric option was the future of Native populations. Although this question is of utmost importance, it is not the province of this paper to discuss it at length. However, suffice it to say that after confrontation and litigation, the parties reached a concerted decision which can be summarized as follows. Native populations obtained exclusive hunting and fishing rights to certain lands which are mostly concentrated along the James Bay coast. They also obtained a financial compensation of $150 million, and finally, local populations will be assisted in relocating their villages (Anonymous 1976).

Environmental Concerns

When the La Grande project was launched, public environmental concerns were expressed in relation to cultural, socioeconomic and ecological implications (Berkes 1977). Concerns were addressed to the project at large and included: (1) climatic changes and increased probability of earthquakes; (2) flooding and its effects on resources such as forests, beaver and moose; (3) erosion and sedimentation; (4) effects on Rupert and James Bay; (5) potential recreative values of new reservoirs; (6) invasion of virgin lands by southern developers; (7) fate of the Native populations; (8) general lack of data concerning renewable resources and environmental parameters.

The lack of data concerning northern ecosystems created a sense of uneasiness among scientists and became a strong influence in the orientation of the La Grande environmental program. Important components of the latter included the collection of baseline data, the mapping of physiographic elements, and the elaboration of impact assessments, mitigation measures and monitoring programs. These activities took place while full scale construction was in progress and it remains difficult to establish the total input of environmental efforts into the project development.

Evolution of Approaches

Since the creation of the environmental divisions of SEBJ and SDBJ in 1971, there has been a large array of approaches used to get the work done. The $10 million environmental program implemented for La Grande included the participation of crown corporations, government agencies, universities and consultants (Soucy 1978). The opportunity to develop scientific expertise in northern ecosystems was unequalled. However, the results presented at symposia and scientific conferences indicate that full advantage was not taken of the opportunity. One of the reasons for this seems to be that the program bogged down in an orgy of data collection without the benefit of the application of scientific methods.

In Québec, fisheries had been the major interest of the francophone universities, with very limited interest in terrestrial ecology. In recent time the accent on fisheries seemed to be waning and animal behavior has been gaining popularity. From this background, it was not surprising that the first phase of studies on the La Grande complex dealt almost exclusively with aquatic ecology. Because of lack of experience and lack of background data, emphasis was placed on data collection. It soon became evident that data were accumulating faster than they could be analyzed, and secondly that SEBJ was locked into an almost exclusively aquatic program.

SDBJ, on the other hand, having started their environmental program a little later, leaned toward systems analysis and stressed physiographic analysis of terrestrial and shoreline sites and population studies through habitat stratification.

The NBR project is handled quite differently by SEBJ. While the final engineering design and mode of operation are still largely undetermined, environmental studies have been in progress since 1976 and a preliminary impact identification has been completed. Two features of the NBR program constitute significant improvement since the beginning of the La Grande development. The first one is that environmental scientists have been working in close association with the engineering team since the beginning. Thus environmental inputs have been injected in the planning phases of the project. The second one deals with Native populations. Whereas interaction with Native populations were often tense in the early stages of the La Grande complex, a structured protocol is now in effect for the NBR project as a result of the signing of The James Bay and Northern Quebec Agreement (Anonymous 1976). The Agreement sets the rules of the game and Native populations have definite rights which must be respected. All new large projects are bound to an impact evaluation process and to the determination of repercussions associated with project implementation. Thus a series of meetings has been held to inform local Native populations of various aspects of the planning and environmental problems of the project. These discussions are still in progress and will continue while alternatives are open. These meetings will be held through the mitigation phase.

Since Hydro-Québec is responsible solely for energy development and not all local resources as in the case of SDBJ, their task is somewhat easier. As a spin-off from public concern and criticism over the James Bay projects, Hydro-Québec, away from the limelight, developed its own environmental division. It started as a small unit and gradually developed into a sound multidisciplinary team of scientists. Hydro-Environment was thus able to handle subsequent large projects such as the Great Whale complex and the Romaine River project. In both cases, the mapping of physiographic features and the collection of baseline data are well underway and, in some cases, near completion. In the case of the Great Whale project, a continuous series of revised impact statements has been produced as specific problems became better defined. The Romaine project is not as advanced and results of the 1978 summer surveys are still being analyzed. In both cases, the environmental group and their consultants have been in close contact with the engineers throughout the planning stages. This liaison is likely to influence the final designs and modes of operation without major confrontations.

The interactions between the environmental team and the engineering groups has evolved by "leaps and bounds" and the dialogue has reached a high degree of maturity even within the La Grande complex itself (Therrien-Bolullo 1978). For instance, access roads, airports and campsites which in earlier days were located merely for convenience are now located according to integrated information concerning physiographic features and the resource base. Environmental programs nowadays are extended to the four seasons; they are well supported and equipped, and finally, they are not considered parallel activities anymore but indeed part of the whole development.

Other important aspects of the evolution of environmental programs are illustrated by the different approaches taken by SEBJ and Hydro-Québec. The SEBJ program elaborated for La Grande was all encompassing and was carried on a very broad front. As a result, it produced great quantities of data which were often of dubious value for management or mitigation. As real problems became defined, new crash programs had to be activated, often without the benefit of basic resource data. Finally, a great portion of the La Grande program seemed to have become oriented towards solving crisis and developing environmental protection guidelines. The long delays required to translate data into information or guidelines useful for field work crews reduced the efficiency and credibility of the environmental program.

In the light of these shortcomings, Hydro-Québec's environmental program for Great Whale was oriented differently. At first, senior scientists met with the chief project engineer to discuss the project and its negotiable features. Senior scientists then made a preliminary assessment of the territory's resources and determined important areas of concern. A triage was carried out and priorities were given to specific problems. Finally experts were hired to conduct research to answer specific problems. This flexible perspective allowed the group to perform detailed scientific studies on specific problems and to drop irrelevant or unfounded concerns from the program. In practice, Hydro-Québec could stop studies with diminishing returns. The final result seems to be a better balanced mission-oriented project based on needs, without preference or privilege given to certain species or scientists.

The general acceptance of environmental programs by senior engineers of the La Grande complex and the maturity achieved by such programs are direct outcomes of the trials and errors of the early activities carried out for the first reservoir and powerhouse (LG-2). The La Grande complex is an integrated development and now that LG-2 is built and the reservoir is filling up, it may remain difficult to inject major modifications into the designs and modes of operation of downstream or upstream developments (LG-1, LG-3, LG-4). The stigma of the almost exclusively aquatic program remains and although the seriousness of the program is no longer questioned, mitigations will probably deal exclusively with the aquatic systems. The maturity has transpired into Hydro-Québec's programs and into the NBR complex. Although these programs remain untested in terms of final results, it is expected that improvements will be significant.

Impacts

The broad array of habitats found in Northern Quebec results in very different impacts from site to site. As our general knowledge of the north increases, predictions seem to be more refined and range from the general, in terms of trade-offs in nutrient cycling, to the particular impacts on specific local fish and wildlife populations. The following description of the areas under development is an attempt to encapsulate a large problem into a few statements.

Physiographic Elements

The areas considered for development comprise a mosaic of distinct habitats which are the result of the regional differences in climate, soils and topography. The climate of the James Bay development area is influenced by the relatively shallow and warm James Bay, while that of Great Whale is affected by the deeper colder Hudson Bay. The Romaine is under the influence of continental westerlies but being so close to the Atlantic Ocean, it often becomes affected by East Coast maritime circulations.

Most of the soils within the developments are of glacial till origin. However, the post glaciation Ojibway-Barlow Lake and the Tyrrell Sea have left large areas of lacustrine and marine clays. Most of the NBR project would be within the Ojibway-Barlow lake bottom. Thus the topography of this region is rather flat and drawdowns associated with future hydroelectric operations will affect very large areas. In the La Grande area, the greatest portion of the development lies close to the Tyrrell Sea boundary, thus little of the more fertile soils of the region will be impounded. Because of the hillier nature of the La Grande region, the area affected by drawdowns will be relatively much smaller than in the NBR project. The topography of the Great Whale region is very different. The average elevation reaches about 600 feet (200 m) within 5 miles (8 km) of the coast whereas in the La Grande sector of the James Bay Territory, 600 feet (200 m) elevation occurs about 50 miles (80 km) inland. The major hydroelectric development site for the Great Whale complex will be very close to the coast, thus the impoundments will flood a much greater proportion of the marine clays than will the La Grande project. Finally, the topography of the Romaine watershed is functionally rather similar to that of the Great Whale area; within a few miles from the Gulf of St. Lawrence, the elevation rises abruptly from the lowlands to the Labrador plateau. The rapid change in elevation represents an insurmountable obstacle for the Atlantic salmon. Finally there are practically no rich marine or lacustrine soils in the Romaine region.

Particular Faunal Assemblages

From the brief physiographic description above it is almost redundant to mention that the faunal and floral communities differ from project to project and also that we can expect sharp limits to these, rather than a gradual change from north to south. In essence, boreal and parkland species are found in the James Bay area, while the Great Whale watershed fauna and possibly that of the Romaine are transitional between boreal and arctic. Bider (1976) perceives the western section of Québec as being formed of six biotic provinces; three being dependent on the latitudinal elements and each being subdivided into clay and glacial till regions. The following statements about the regional fauna will help to set the perspective.

Moose, beaver, sharptail grouse, several species of frogs, one salamander, one snake, pike and walleye are all characteristic of the James Bay region but are scarce in the Great Whale watershed. One study (Bider and MacCulloch 1973) indicated that, at the northern limit of the James Bay territory, the American toad *(Bufo americanus)* was the most active species of the terrestrial vertebrates. Caribou, ptarmigan, geese, substantial breeding populations of ospreys, common and surf scoters, inland nesting harlequin ducks and red-throated loons, colonies of arctic terns, lake trout and whitefish characterize the Great Whale region. This section of the Hudson Bay coast may be the only place where one can hear toads trilling and ptarmigan calling at the same time. At the northern edge of the Great Whale development, there is the Lower Seal Lake with its isolated population of dark freshwater harbour seals described by Twomey (1942) and its fish populations, which have been modified by the predatory seals (Power and Grégoire 1978). The lower section of the Romaine river is characterized by the presence of Atlantic salmon.

Some Impacts

The most striking general observation that results from winter surveys of the area and which were confirmed by several studies in the La Grande and Great Whale areas during the summer is that the terrestrial fauna is sparse but often concentrated in or near riparian vegetation. A retrospect survey carried out by Hydro-Quebec in 1973 showed that after 50 years the shorelines of the Gouin reservoir in the south had nearly all stabilized but had not developed an ecotone of riparian species found on the edges of non-flooded adjacent lakes. Thus we feel the loss of shoreline will be a major impact on the terrestrial community.

Along the length of most northern rivers there are areas where rich alluvial soils have been deposited and these support important stands of willow, alder and grasses. The flooding of these areas will represent a trade-off between: (1) the losses of habitat for hare, ptarmigan and geese, and (2) a gain in sucker and whitefish productivity and biomass. Perhaps, within the Tyrrell Sea, partially dried out sections of rivers will eventually turn into some appreciable willow stands and at least in part mitigate the losses from within the impoundments.

Rivers as such are not as productive as lakes. However, in this nutrient-poor region, rapids, particularly at the discharge of large lakes, contain a host of invertebrate species which can filter the sparse nutrients, thus creating the basis of an animal community which is truly remarkable. Not only does the production of invertebrates sustain fish such as trout, whitefish and suckers, but they also act as a food basis for terns, swallows and a host of terrestrial passerine birds which feed on adult emergent insects in the riparian vegetation. Near every rapids is the ubiquitous set of osprey nests along with the otter, mink and mergansers, all of which feed on the concentrations of fish. Though the productivity of phytoplankton and benthic species decreases as one moves downstream, each rapids constitutes an area where the poor resources are sufficiently concentrated to support terrestrial and avian carnivores. As a result of this scenario, it is relatively certain that bottom feeders such as suckers will be the greatest beneficiaries of the impounding of the fast water while the terrestrial and avian resources will probably lose out.

In the central regions, the submergence of islands which are secure from fires will diminish winter caribou habitat. The loss of open water in spring could adversely affect waterfowl such as scoters and oldsquaws which cross Quebec, presumably from the Atlantic to the west coast of Hudson Bay and the Arctic, and seemingly depend on these areas for resting and possibly even feeding during spring migrations.

Legislative Measures

Several pieces of legislation passed or under study by the National Assembly will have a significant effect on the management and conservation of northern Québec's renewable resources. Fish and wildlife resources are protected by Bill 53 which regulates hunting and fishing. Although the immense territory represents a great challenge for the few game wardens, they have in the past visited advance camps and issued summons. Impact assessments and the respect of pollution standards will be mandatory under Bill 69, presently under study. Impact assessments will determine whether or not a construction permit can be issued by the director of the Québec Environmental Protection Services. Bill 19 empowers the Ministry of Tourism, Fish and Game to create "conservation parks," which may be required to insure the protection of certain northern habitats or populations such as the landlocked seals.

The most significant piece of legislation is Bill 28 which outlines the details of the settlement with the Native populations concerning renewable resources. Two aspects of the law are noteworthy in terms of fish and wildlife resources. First, it recognizes a land classification which gives Native populations exclusive rights to harvest fish and wildlife in certain areas of the James Bay Territory. Secondly, the Department of Tourism, Fish and Game is empowered to adopt regulations concerning quotas, management practices, protection measures for vulnerable species and research projects on fish and wildlife.

Summary and Conclusions

Since 1971, the development of northern hydroelectric potential has produced a large number of environmental studies in Québec (Anon. 1978, Magnin 1977). In many ways, the La Grande complex was a first and it soon became apparent that it was impossible to study all aspects of the environment to the same degree. The areas were too large, time was too short and logistic problems were significant. When the project became public, initial environmental concerns were global in nature and were related to large surface areas. However, the heterogeneous distribution of resources and generally low productivity eventually indicated that it was more advantageous to concentrate on specific environmental problems.

Up to the mid sixties, vertebrate biologists in Quebec were mostly fisheries biologists, thus at the time of planning the La Grande project it could well be that the great imbalance between aquatic and terrestrial biologists available to work, influenced the orientation of the program. The over-structured all-encompassing approach lacked flexibility and produced great quantities of data but restricted discussions to aquatic ecology, and knowledge relating to terrestrial or avian populations was slow to emanate.

Another lesson to have emerged from the La Grande complex is the lengthy and energy sapping multidisciplinary effort to elaborate comparative environmental impact assessments. Since impact assessments are vital in deciding which projects will be carried out next, great concerns were expressed that assessment methodologies enable comparisons between two or more proposed projects. Since it appears that all projects will be implemented eventually, and because the physiographic and biological elements are so variable, the search for universal programs to compare impacts is losing favor. Instead there seems to be an increasing interest in being more selective in accumulating data, keeping assessment at the resource and project level, and getting into research directed toward mitigation and management. Legislation makes impact assessments mandatory and perhaps the legal framework will result in greater uniformity of approach, but the value of this is questionable because all-encompassing systems often end up as a series of value judgments comparing noncomparable elements. Impact assessment may be more useful if the results are integrated and interpreted to identify key problem areas.

Just as primitive tents gave way to house-trailers, recreation centers and medical facilities, the environmental programs developed maturity. Communications between ecologists and engineers have evolved into a true concerted dialogue. Early surveys, for the La Grande complex, were almost exclusively restricted to the summer period and logistic support often was lacking. Nowadays, surveys have become year round exercises with adequate and flexible logistic support. Finally, static data banks are in the process of generating ecological models. Despite some misgivings along the way, it would be an exercise in second-guessing to try to determine the results of a different approach. We must consider the experience, the failures and the accomplishments, as positive steps towards the development of scientific expertise for the future in order to insure proper management of Québec's northern renewable resources. Finally, although not discussed in the present paper, a major area of concern in northern latitudes is the presence and role of the Native people. Traditionally, their lives have been closely associated with the fish and wildlife resources. The hydroelectric developments produce new knowledge and access to resources which will make their management a very difficult task. It must be the goal of all large northern projects to develop a better understanding of Native peoples' aspirations in terms of natural resources. Otherwise, the management, the control and the conservation of fish and wildlife resources remain very uncertain.

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The Alaska Oil Pipeline in Retrospect

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The Trans-Alaska Oil Pipeline stretches 800 miles (1288 km) from Prudhoe Bay on Alaska's Arctic coast across three mountain ranges, intervening tundra, forest and perennially frozen ground to the icefree port of Valdez on the North Pacific Ocean. The construction project included a 48-inch (1.22 m) diameter hot oil pipeline, 8 pump stations, a communications system, and the 1,000-acre (4 km^2) terminal at Valdez, and was completed in just 3 years at a cost of nearly $8 billion. The project is considered the largest single commercial construction work of mankind.

This gigantic project, rushed to completion in arctic and subarctic environments that had been largely foreign to oil industry technology, held the potential for massive environmental degradation. The pipeline corridor contained habitats, migration routes, seasonal movement zones, and lambing and calving areas for numerous species of wildlife. Brown and black bears, caribou, moose, bison, Dall sheep, mountain goats, wolves, foxes, coyotes, wolverines, hares, marmots, and other fur bearers and small mammals were known to use the corridor at least seasonally. An estimated 194 species of resident and migratory birds were present along or adjacent to the pipeline route. The designated pipeline route and the associated 360-mile (580-km) haul road would cross approximately 500 fish streams containing more that 40 species of fish (U.S. Department of the Interior 1972).

It is now almost 2 years after the first oil began to flow in the line, and timely to ask what we have learned from the project that can be applied to future large developments in the North. What sacrifices of fish and wildlife resources were made for the sake of the project and its expeditious completion? In retrospect, were these losses necessary and were they minimized through proper planning and the development of suitable environmental stipulations? How was the environmental surveillance system organized; did it effectively protect fish and wildlife during construction; and does this system present a suitable model for other projects of comparable magnitude? The answers to these and related questions, regardless of the overall merits of the project, should provide not only insight into the environmental problems associated with massive construction projects in the North but also a background of experience for dealing with such projects in the future.

Oil was discovered at Prudhoe Bay in January 1968, but it was not until January 1974 that the Federal Government granted the right-of-way for the pipeline and not until the following May that the State of Alaska granted a similar permit, clearing the way for construction to begin. This delay was the product of events traditionally associated with oil field development as well as other events unique to the project. Initial testing of the oil field (estimated at 9.6 billion barrels) and preparation of the plans for pipeline construction took a year and a half. It was anticipated that authorization for construction of the pipeline would be made by the President under provisions of the Mineral Leasing Act of 1920. However, as a result of growing national concern for the environment, in late 1969 Congress passed the National Environmental Policy Act which required that all major projects undertaken on federal land be preceded by a statement of expected environmental impacts. The Trans-Alaska Pipeline was clearly covered by this Act, since the pipe would cross nearly 550 miles (880 km) of federal land. Suits had been filed in April 1970 by various environmental groups challenging the authority of the President to authorize construction of the project. The draft environmental impact statement (EIS) for the project was not prepared until January 1971. Questions arose over the adequacy of the EIS in assessing the total impact of the project and these questions were compounded by the failure of Alyeska Pipeline Service Company (the consortium of seven oil companies formed to construct and operate the pipeline) to provide the necessary background information on soil conditions, permafrost, and associated pipeline design to enable the final revision of the EIS, which was not released until March 1972 (U.S. Department of the Interior 1972). Finally, in November 1973, Congress passed the Trans-Alaska Pipeline Authorization Act in the midst of a national energy crisis, thereby obviating the provisions of the National Environmental Policy Act.

Work began on the gravel haul road from the Yukon River to Prudhoe Bay in April 1974 and the first pipe was laid in March 1975. The delay between oil discovery in 1968 and initiation of construction allowed state and federal governments and industry to carry out short term environmental and engineering studies, which led to revisions in pipeline design and construction planning, thus reducing the potential environmental impact of the project. The news media carried stories often blaming environmentalists for the long delay before construction started, but some spokesmen for industry and many from government acknowledged the advantages that had accrued as a result of the delay. These advantages were reflected in a more environmentally sensitive pipeline design and a more comprehensive set of environmental stipulations governing construction. In spite of increased consideration of environmental values along the pipeline route, state and federal fish and wildlife biologists point out that selection of the route of the pipeline was completed before basic environmental studies had been done and was largely a choice made by industry to meet engineering and monetary considerations. The initial routing of the line did not take into consideration the importance of fish and wildlife populations and habitats along the way, nor was there basic information available at that time to do so. A few minor changes in pipeline routing were made when specific problems related to fish or wildlife became apparent.

Development of Surveillance System

Before construction began on the pipeline project, a detailed set of environmental and general stipulations to guide construction was developed under authority of the U.S. Bureau of Land Management (BLM), with broad participation from state and federal fish and wildlife biologists and industry representatives (State and Federal Stipulations 1974). These stipulations were comprehensive, in view of the short time available for their formulation and the fact that industry had never before been expected to comply with such restraints. A major shortcoming of the stipulations, and particularly those dealing with fish and wildlife, resulted from the failure of industry to provide details of the pipeline alignment, design, and construction modes as the basis for anticipating specific problems that might develop. Alyeska took the position that final details of construction, scheduling, design, and alignment could not be decided until just before actual construction because of continuing modification as new information was generated from ongoing engineering studies. Moreover, realignment for environmental reasons was difficult to accomplish once the routing had been decided by engineers. As a consequence, the stipulations had to be of a general nature, setting broad standards rather than dealing with specific situations. The difficulties associated with permafrost, floodplain and river crossings, and earthquake zones proved to be much more serious than industry spokesmen had indicated. Because many specific problems related to fish and wildlife could not be anticipated without details of pipeline design and construction, it was not possible for state and federal biologists to initiate explicit studies aimed at gaining knowledge to resolve or reduce the problems.

The final stipulations that were issued concurrently with the EIS represented compromises reached by geological and engineering experts and fish and wildlife biologists of the state and federal governments and representatives of Alyeska. Biologists who had been involved in developing the stipulations were concerned about their lack of specificity and the questions of how the stipulations would be enforced and who would have the discretionary authority that was written into them (Morehouse et al. 1977). From the beginning of the planning phase for the pipeline, state and federal fish and wildlife agency staff members cooperated closely. Initially, this cooperation was in the absence of any formalized structure and is to the credit of the biologists involved that their commitment to the fish and wildlife resources overrode possible interagency rivalries or jurisdictional disputes. This cooperation was later formalized through interagency agreement. The tremendous effort involved in developing both the environmental stipulations and the EIS also pointed up the need for continued participation of fish and wildlife biologists in collection of specific information that had been identified as crucial and to provide the expertise necessary to make the day-to-day decisions that would be needed when construction began. Since pipeline construction could not be delayed until all of the possible conflicts with fish and wildlife resources could be investigated, it was apparent that fish and wildlife biologists would have to be actively involved in the construction process.

The Joint State/Federal Fish and Wildlife Advisory Team (JFWAT) was officially established in May 1974. This team was granted advisory authority and was expected to work for the protection of fish and wildlife resources during pipeline construction. The team consisted of 31 professional staff, including 16 from federal agencies (11–U.S. Fish and Wildlife Service; 3–National Marine and Fisheries Service; 2–BLM) and 15 from the Alaska Department of Fish and Game. The advisory authority of JFWAT was exercised directly through two offices that had been established at federal and state levels to oversee the construction of the pipeline and to ensure compliance with the terms and conditions of the pipeline right-of-way agreements and related authorizations: the Alaska Pipeline Office (APO), headed by the authorized federal officer and the State Pipeline Coordinator's Office (SPCO). In addition to the authority exercised through the APO and SPCO, JFWAT also had statutory obligations through its parent agencies for the Fish and Wildlife Coordination Act of 1934 (relating to impoundment or divertion of navigable waters); the Endangered Species Act of 1973; the Bald and Golden Eagle Act of 1940; and sections of the Alaska Statutes (relating to conservation, development, and regulation of fish and wildlife resources within the state). The primary advisory role of JFWAT was greatly strengthened because the terms of the pipeline construction agreement required issuance of special permits to meet the terms of all this legislation. This stricture was particularly important with regard to fishery problems, since the Alaska Statutes require a separate permit for each crossing of an anadromous fish stream, as well as for a number of related activities (such as gravel removal from flood plains, blasting near these sensitive areas, and waste discharges affecting anadromous fish streams).

Initially there was disagreement as to what constituted anadromous fish streams but this was largely resolved, administratively at least, through the issuance by the Alaska Department of Fish and Game of a revised *Anadromous Fish Stream Catalogue* (March 1975), including all tributaries of known anadromous fish streams in the state. This updated and broadened classification in effect made nearly every stream affected by pipeline construction subject to permit requirements under the Alaska Statutes although this authority was not exercised in all stream crossings.

The Endangered Species Act provided the leverage necessary to reroute the haul road away from Sagwon Bluffs and to re-site Pump Station 2 away from this location, the site of nesting eyries for the peregrine falcon and other raptors. Pipeline construction in the area was also curtailed during the raptor nesting period (Klein and Hemming 1977).

The functional responsibilities of JFWAT included design review, field surveillance, and technical evaluation. The nine-member design review staff in Anchorage coordinated with the APO and SPCO in the review of documents submitted by Alyeska whenever questions of fish and wildlife resources were involved. Since fish and wildlife values were at least potentially influenced by all aspects of pipeline design, support facilities, and construction scheduling, JFWAT reviewed essentially all material submitted by Alyeska, which amounted to a prodigious amount of paper work (Kavanagh 1977).

In the field, JFWAT monitors lived in the pipeline camps and used vehicles assigned by Alyeska. The entire JFWAT operation was reimbursable to the Federal Government and the State of Alaska by Alyeska under terms of the federal and state right-of-way permits. JFWAT pipeline monitors operated directly within their own administrative structure as well as through the field representatives of the APO and SPCO. At times this dual responsibility led to misunderstandings, but it also provided more than one route of communication to the central offices in Anchorage and Fairbanks, which proved useful in instances where differences of opinion between biologists and engineers could not be resolved in the field.

The technical evaluation function of JFWAT involved specific field investigations which were designed to answer pipeline-related questions that had been raised during the development of environmental stipulations in the preconstruction planning phase. Personnel involved in these investigations, although funded through JFWAT, worked largely through their own agency offices. There were eight technical evaluation projects: two dealing with effects of the pipeline on caribou and moose movements, three investigating specific river system drainage problems, one evaluating fish and wildlife habitat along the pipeline route, one gathering stream quality baseline data at pipeline crossings, and one evaluating subtidal effects of the terminal construction at Valdez. Results of these investigations have been released in a JFWAT technical report series.

Effectiveness of the Surveillance System

Functionally, the only effective surveillance of pipeline and related construction activities in relation to fish and wildlife resource values was through JFWAT. An attempt at citizen involvement in pipeline surveillance by several environmental groups through the Arctic Environmental Council provided only limited access to the project and only superficial evaluation of compliance with environmental stipulations. Minimally funded through the Arctic Institute of North America, the Arctic Environmental Council was unable to employ adequate support staff and remained dependent upon Alyeska for background information and financial support, thus depriving it of its intended independence from the interests of the pipeline company. Environmentalists in general were critical of both Alyeska and the responsible government organizations for not providing free access to the project for representatives of the news media as well as environmental groups. The press played a role in providing support for fish and wildlife surveillance activities by printing news (often leaked by pipeline workers and state and federal surveillance officers) of problems in compliance with the environmental stipulations. When specific problems were brought to the attention of the public it was often easier for the APO or SPCO to press for compliance with environmental stipulations, even in the face of threats by the pipeline company of construction delays and escalated costs.

Stream Crossing Problems

The major focus of JFWAT's attention was on stream crossings because of the number of crossings involved, the diversity of riparian and hydraulic conditions encountered, and the lack of previous experience with the effects of major construction activities on northern fish streams. Most of these problems involved placement of culverts and construction of low water crossings (fords) that failed to meet fish passage requirements. Correction of violations was often delayed for as much as 2 years.

Little was known about the streams before construction and differences of opinion often arose over their importance to fish, their flow characteristics, and consequently the design of the specific crossings. Alyeska engineers, with little or no experience with streams in arctic and subarctic areas, frequently underdesigned crossing structures. Low water crossings, intended to avoid problems with culverts, as well as to reduce costs, proved in most cases inadequate to handle the heavy equipment which was used in construction activities. The resulting maintenance and subsequent culverting or bridging that were often required caused additional stream disturbance and siltation and escalated construction costs (Gustafson 1977).

A complaint frequently voiced by JFWAT field monitors was their inability to convince Alyeska construction engineers, as well as those engineers who were APO or SPCO field representatives, of the severity or urgency of a particular stream crossing problem. On the other hand the lack of extensive construction training or experience on the part of JFWAT biologists has been cited as a complicating factor in resolving these problems (Norton 1976, Morehouse et al. 1977, Kavanagh 1977).

Large Mammal Crossings

The question of the effect of the pipeline on the free movements of large mammals (particularly caribou, but also moose, mountain sheep, and bison) was one of the most emotional issues during the debate over the routing and construction mode of the pipeline. Preliminary studies with simulated pipelines at Prudhoe Bay and on the Seward Peninsula showed that under most conditions caribou would not readily cross under an elevated pipeline (Child 1973, Child and Lent 1973). On the basis of these studies and experience with pipelines and other obstructions elsewhere (Klein 1971), one of the environmental stipulations in the state and federal right-of-way agreements required that the pipeline be constructed "both buried and above-ground sections, so as to assure free passage and movement of big game animals" (State and Federal Stipulations 1974: Sec. 2.5.4.1). Although it was recognized that any above-ground pipeline would probably interfere with the free passage of caribou and possibly moose, at the time there was insufficient experience with elevated pipelines and large mammals to enable design of pipeline crossing facilities to assure their free passage. Nevertheless, state and federal biologists, working with Alyeska representatives, developed standards for large mammal crossings on the basis of the limited information available (JFWAT 1977). These standards were considered by the biologists to be a minimally acceptable compromise.

About 420 miles (675 km) of the pipeline were to be elevated because of permafrost soils with high ice content. Numerous large mammal crossings of specially buried sections (primarily for caribou) and elevated sections with increased clearance (primarily for moose) were to be built along the route. These included 24 short buried sections of 60 to 120 feet (18 to 36 m) secured to adjacent vertical supports (called "sagbends") and several hundred elevated crossings a minimum of 10 feet (3 m) high and 60 feet (18 m) long. In addition, at two locations where the pipe crossed a caribou migration route, the pipe was buried for several miles in a specially refrigerated mode to prevent thawing of the permafrost (JFWAT 1977). Records of the APO and JFWAT show that 157 of 550 buried and elevated crossings failed to meet the standards that had been agreed upon (Morehouse et al. 1977). Most violations of crossing standards were those where the clearance below the elevated pipe fell short of the required 10 feet (3 m), and JFWAT biologists attributed these violations to failure in Alyeska's quality control program that was intended to assure that construction proceeded according to design specifications. Alyeska requested a waiver of the standards and the request was denied. Alyeska delayed correcting the crossings, which in most instances involved excavating the underlying work pad, for up to 2 years.

Technical evaluation studies of the effectiveness of large mammal crossings in providing free access for both moose and caribou were initiated by Alaska Department of Fish and Game Biologists through JFWAT (Van Ballenberghe 1978, Cameron and Whitten 1978). Adjacent to a 70-mile (117-km) elevated portion of the pipeline in south-central Alaska, 208 moose were individually marked with numbered collars or radio-collars to enable monitoring of their movements. Results of this study show that these moose were seasonally migratory and that 57 percent of the 1,068 successful crossings of the pipeline occurred where ground to pipe clearances were between 6 and 8 feet (1.8 and 2.4 m) (Van Ballenberghe 1978). Some moose crossed the pipeline where it was as low as 49 inches (1.25 m), but many others were deflected by the pipeline and in 14 instances moose failed to cross. Van Ballenberghe (1978) concluded that during winters when snow depth exceeds 30–40 inches (0.76–1.02 m) and clearance under the pipeline is greatly reduced, the pipeline would be a much greater deterrent to the movement of moose.

Caribou have not fared as well as moose in adjusting to the presence of the pipeline. Research adjacent to the pipeline and haul road on the North Slope from the Brooks Range to Prudhoe Bay shows that caribou from the Central Arctic Herd have altered their movements and patterns of range use in relation to the pipeline corridor. The central Arctic Herd numbers about 6,000 animals and its movements are restricted to the North Slope, with calving and summer distribution on the coastal plain and winter concentrations primarily in the foothills. Winter movements and range use patterns do not appear to be altered by the pipeline and adjacent road, but the frequency of caribou–pipeline encounters is low. However, at the time of calving and throughout the summer until rut, cows with calves show a pronounced avoidance of the pipeline, road, and the Prudhoe Bay oil field. Bulls do not show this type of avoidance. It appears that traffic and other human activity are more directly responsible for the avoidance behavior of cows with calves than the physical presence of the pipeline, haul road, and other facilities. Cameron and Whitten (1978) have recognized the possibility of fracturing of the herd if the pattern of avoidance of the pipeline by cows and calves continues. Gavin (1978), who has been employed by the oil industry, maintains that there has been no significant effect on caribou of the Central Arctic Herd as a result of the oil field development and pipeline construction. However, his conclusions are based on intermittent summer observations that were incidental to other wildlife observations.

Other Fish and Wildlife Problems

During the period of intensive construction activity several problems related to fish and wildlife escalated far beyond expectation. The environmental stipulations required prompt incineration of all garbage at construction camps to avoid attraction of bears and other scavengers. Alyeska also cautioned workers during indoctrination sessions and posted regulations against feeding of wild animals under threat of termination of employment. Nevertheless, attraction of bears, foxes, ravens, gulls, and other wildlife to construction camps through improper garbage disposal, and taming of wolves and other carnivores through food handouts by workers continued to be a problem that plagued JFWAT biologists throughout the construction phase. Not only were "garbage" bears a threat to life and property, but tame foxes and wolves posed the threat to workers of rabies and the individual animals turned panhandlers were aesthetically degraded and their ecological relationships disrupted. The few employees who were fired for feeding animals were usually rehired to a different segment or contractor on the line (union contracts prohibited blackballing of individual offenders). Finally, after thousands of dollars and many man hours had been spent in moving or killing nuisance bears, the Alaska Board of Game imposed a regulation (July 1976) under the State Statutes making it a misdemeanor to offer food to bears or other carnivores in the pipeline corridor, or to improperly dispose of garbage so as to attract wildlife. Nevertheless, enforcement of this regulation continued to be a problem (Milke 1977). Solution to the problem of attraction of animals to food sources on large construction projects appears to lie in a commitment by the builders to the importance of the problem, education of the workers, and strict and effective enforcement of regulations.

A problem which proved difficult to deal with was the harassment of wildlife by low-flying aircraft. Technically, Alyeska maintained authority over all construction-related activities within the pipeline corridor and in some areas of wildlife concentrations minimum flight altitudes were prescribed. Helicopters and other small aircraft involved in the project, however, were usually under third-party contracts and not directly subject to Alyeska's authority. As a result, although pilots were cautioned about low level flights over conspicuous wildlife and violators were threatened with disciplinary action, wildlife was often deliberately harassed. These incidents usually involved grizzly bears, mountain sheep, caribou, moose, or wolves and the motives were apparently curiosity or photography.

Several studies into the behavioral reaction of wildlife to low flying aircraft (Klein 1973, Calef et al. 1976, Miller and Gunn 1978) have been made, but there has been little investigation of the consequences for the animals of such harassment. The assumed detrimental effects on the wildlife involved are therefore based on extrapolation from experience with domestic reindeer and experimental work with laboratory animals (Geist 1975). Given the information available and the logic employed, these assumptions appear sound, but pilots and industry representatives have been understandably skeptical of the extrapolations upon which they are based. Additional research is clearly needed.

During the pipeline planning stage the oil industry placed strong emphasis on its commitment to construction of the pipeline with minimal impact on the environment. The high frequency of spills of fuels and lubricating oils during the project and the laxity in reporting of spills and in initiating containment and cleanup action were therefore expected (Zemansky 1976). The reluctance of Alyeska to deal effectively with this problem may have been associated with a desire to protect its public image, however, because of eventual press coverage, the reverse was usually the result. Several minor spills and a few major ones occurred with petroleum products entering streams and lakes (Kavanagh and Townsend 1977). The effects of fuel spills on fishery resources have not been well documented, although a reduction of densities and species diversity of aquatic invertebrates in affected systems has been reported (Bengtsson and Berggren 1972).

Biologists who had worked with JFWAT and are now employed by the Alaska Department of Fish and Game (JFWAT was disbanded Dec. 31, 1977) are continuing to work with Alyeska personnel over the question of rehabilitation of fish and wildlife habitat that was destroyed or degraded as a result of pipeline construction. A major difficulty in reaching agreement as to Alyeska's responsibility in habitat rehabilitation is the inadequacy of baseline information against which to compare the construction effects. Primary focus has been on riparian habitat that was destroyed or altered through the removal of gravel for construction purposes. This activity often resulted in the elimination of extensive stands of willows which were of prime importance for moose and other wildlife, especially in the Brooks Range and North Slope areas where such habitat is very limited in occurrence and is the only available wintering habitat for moose.

Indirect and Long Term Effects on Fish and Wildlife

Experience with obstructions to movements of caribou and wild reindeer elsewhere (Parovshchikov 1965, Klein 1971) and knowledge of the behavioral reaction of the species to environmental conditions and disturbances (Thomson 1972, Sharp 1977, Roby 1978) suggest that the 4 years since the beginning of pipeline construction is an inadequate period to assess the response of caribou to pipeline-related impacts. The next several years represent a unique opportunity to document the response of a caribou population to known disturbances associated with a large-scale northern development project. Knowledge gained from this experience would be immensely valuable in planning for other large projects in the future. Unfortunately, Alyeska has terminated support for continued monitoring of the movements of caribou, and moose adjacent to the pipeline, and funds available to the Alaska Department of Fish and Game appear to be inadequate to provide for continuation of these studies.

It is now apparent that many of the fish and wildlife problems associated with the pipeline project were limited to the construction phase and were largely a product of the intensity and rapid pace of activity and the large numbers of people involved. With completion of the project, direct physical disturbance of fish and wildlife habitat has essentially ceased and the people-related problems of wildlife feeding and harassment have abated. However, longer lasting effects should be monitored so that their consequences can be assessed. This monitoring should be done so that all of the environmental costs of the project can be weighed against the benefits received, and to provide information that will be useful for planning other large projects in the North.

The effects that should be monitored include the long-term consequences of stream channelization and gravel removal on fish habitat; the effects of fallout of SO_2 and other atmospheric pollutants generated at Prudhoe Bay and by the pumping stations on lichens and other vegetation that are the food base for wildlife; the ability of caribou (particularly cow–calf pairs) to adjust to industrial development; and the effects of road dust from the haul road in causing early snow melt on the adjacent tundra of the North Slope. Unfortunately, neither industry nor government has assumed responsibility for the long term monitoring of these consequences of the pipeline project.

An indirect effect of the pipeline project has been that a vast wilderness area north of the Yukon River containing relatively untapped fish and wildlife resources has now become an area served by an all-weather road and by numerous airstrips. Intense public interest has been generated in the fish and wildlife, minerals, and other resources of the region. Animals along the haul road are particularly vulnerable to poaching because of the open terrain and the fact that many became tame during the peak of pipeline activity. Poaching, particularly of furbearers, has increased with the decrease in pipeline-related traffic on the haul road. The overall environmental impact of human activities along the haul road will depend to a large extent on the policy pursued by the State of Alaska in providing for use of the haul road by the public. Although the road is now open only for industrial use, local political pressure to open the road to the general public is strong.

A question that was addressed during the pre-pipeline debate, but which has since faded from attention is that of the action to be taken at the end of the life of the pipeline. This decision will be complicated by the construction of a gas pipeline, presumably along a major portion of the oil pipeline route, but ultimately both oil and gas will be exhausted from the Alaskan Arctic. The estimated life of the Prudhoe Bay oil field is 30 years; even with additional oil discoveries and recovery of available gas, it is likely that the oil pipeline and possibly an associated gas line may no longer be in operation 50 years from now. It seems clear that a plan for dismantling the pipeline and pump stations with minimal impact on fish and wildlife resources should be developed well in advance of termination of the project. Such a plan should include provisions for the restoration of fish and wildlife habitat that was lost as a result of the project.

Conclusions

The Trans-Alaska Pipeline project was unlike previous major development projects in that construction took place under a detailed set of stipulations designed to minimize impact of the project on the environment. Also unique was the surveillance system, which included a team of state and federal biologists working jointly to ensure compliance with the environmental stipulations and to address problems related to fish and wildlife that developed as the project progressed. It was demonstrated that protection of the environment could be a guiding principle in a major development program as a realistic projection of the interests of a concerned public.

One of the major shortcomings in the development of the environmental stipulations and in the day to day appraisal of fish and wildlife problems was the lack of adequate background information upon which to make decisions. It is significant that pipeline construction could not proceed until technical studies provided the information required by the design engineers, yet similar delays were not experienced because of lack of biological information.

Biologists and engineers worked together and learned to appreciate one another's viewpoints. Biologists charged with surveillance to ensure maintenance of environmental standards on such projects, however, clearly should have more than advisory authority. Environmental standards, if they are accepted by both government and industry, must be adhered to with the same rigor of quality control that characterized the engineering standards.

Monitoring of longer term environmental effects must be provided for in the initial project planning, with suitable contingency provisions to ensure that unanticipated consequences will not be ignored because they were not dealt with in itial agreements. Knowledge of all aspects of the environmental impact of major projects is of obvious importance in planning future projects. The public must be apprized of the environmental compromises that are made when major development projects are undertaken if they are to participate wisely in decisions which will affect public resources in the future.

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Historical Sketch of the Proposal for an Arctic International Wildlife Range

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Introduction

The unique landforms, ecological diversity, and cultural and archaeological significance of the northern Yukon are part of an irreplaceable natural heritage of regional, national and international importance. The migratory Porcupine Caribou herd is symbolic of this heritage. However, various industrial developments pose a serious threat to the region and its resources. The recently completed Dempster Highway, the plans of Dome Petroleum for access across the North Slope to the Beaufort Sea, and possible authorization of oil and gas exploration in northeastern Alaska are examples of immediate concern. If there is ever a time for "Consolidating Conservation Efforts," it must surely be now. A united front must be formed to develop and support a comprehensive approach to conservation and development for northern Yukon lands and resources.

The Early Years

The history of the proposed Arctic International Wildlife Range (AIWR) has important implications for its current and future status. The term AIWR (Canada) was coined in 1970 at a conference in Whitehorse and refers to the same general area of northern Yukon lands tentatively withdrawn from future development by Hugh Faulkner, Minister of Indian and Northern Affairs, in July 1978 (Communique #1-7821, July 6, 1978). The proposed Canadian reserve adjoins the Arctic National Wildlife Refuge (ANWR) in northeastern Alaska. It was originally anticipated that AIWR would become the name of the combined Canadian and U.S. areas. Today however, AIWR has come to represent the potential Canadian reserve only.

The proposal for a northern Yukon reserve originates from the 1920s when Olaus and Mardy Murie conducted field studies on the Porcupine Caribou herd's range in northeastern Alaska. They were able then to impress upon U.S. officials the conservation value of the Arctic ecosystem. Nevertheless, research did not begin until the 1950s, headed by George L. Collins, then Chief of Land Use Planning for the Western Region of the National Park Service; Lowell Sumner, Chief Naturalist of the Service; and A. Starker Leopold, zoology professor at the University of California (Leonard 1978a).

As part of this renewed interest, biologists, including the Muries, surveyed the upper Sheenjek River drainage in the eastern Brooks Range in 1956. Their studies were supported by the Wilderness Society, the Conservation Foundation and the New York Zoological Society, and provided part of the initiative for the 1957 Sierra Club Wilderness Conference. This meeting focused on northeastern Alaska and the northern Yukon, and was attended by heads of all the U.S. federal land-management agencies and environmentalists from across North America.

The U.S. Arctic National Wildlife Refuge stemmed from the conference's major recommendation for formal protection of the caribou and other wildlife in the Brooks Range area. In part because of objections by mining interests, the formal establishment of such a reserve was not taken up by Congress until December of 1960 when, in the final days of the Eisenhower administration, Interior Secretary Seaton withdrew 8.9 million acres (3.6 million ha) by public land order to establish the Arctic National Wildlife Refuge (ANWR) (Leonard 1978a). Lobbyists for the ANWR also attempted to have a Canadian counterpart withdrawn, but as there was no evidence of any type of threat in the Arctic, there was no Canadian government support for this proposal.

Oil and Gas Discoveries and Conservation Initiatives

In 1968, the situation changed dramatically. The discovery of oil and natural gas at Prudhoe Bay, Alaska, and subsequent exploration in the western Canadian Arctic, resulted in increased pressure on the Canadian government to protect the range of the Porcupine herd in the northern Yukon as a wildlife reserve adjoining the ANWR. George Collins and his conservation-oriented associates attended the International Conference on Productivity of Circumpolar Lands in Edmonton in 1969 with the intention of urging Canadian Arctic specialists to lobby for protection of the northern Yukon lands (Leonard 1978b). Dr. Andrew Thompson, a conservationist and law professor at the University of British Columbia, subsequently organized the Arctic International Wildlife Range Conference, which took place in Whitehorse in October, 1970.

This meeting attracted 66 arctic wildlife specialists, representatives of state, territorial and federal governments, mining, oil and gas companies and Native groups. A majority of participants agreed upon several resolutions regarding the establishment of a Canadian wildlife refuge. This majority stressed the need for formal protection of the northern Yukon under Section 18(e) of the Territorial Lands Act, and for research into possible international agreements for the management of the resources. The principal recommendation suggests:

> . . . that the governments of Canada and Yukon establish an area to be known as the Arctic International Wildlife Range (Canada) with boundaries to be established with reference to suitable landmarks approximately following the Porcupine and Bell Rivers and thence to the Blow River near its mouth, along the arctic coast to the international border and south along that border to the Porcupine River (Arctic International Range Conference 1971).

The AIWR (Canada) Society was also formed, with Dr. Thompson as president and George Collins as vice-president.

Following the Conference, the Hon. Jean Chretien, then Minister of Indian and Northern Affairs (DINA), and participant at the two-day meeting, acknowledged the recommendations and resolutions passed at the Conference and indicated his support for the Range. Additional support came from the 12th Technical Meeting of the International Union for Conservation of Nature and Natural Resources (IUCN) 1972, where a resolution was passed urging the governments of Canada and the U.S. to cooperate in establishing an International Range for the protection of the Porcupine Caribou herd.

The AIWR Conference resolution reached the Order-in-Council stage, but was subsequently dropped by Chretien's office in 1973. The key factor at this time was the increasing concern over land claim negotiations, and the concomitant pressure on government (specifically DINA) to disallow any further land dispositions (Andrew Thompson, personal communication, Oct. 23, 1978). A second factor was the attitudes of mining interests and local chauvinism, expressed through Commissioner Smith's (Yukon) objection. Local residents felt that the Federal Government should not proceed on decisions having major effects on the Yukon until the issue of provincehood was settled (Andrew Thompson, personal communication, Oct. 23, 1978).

The Berger Inquiry

DINA therefore kept the proposal shelved until an upsurge in interest occurred during the Berger Inquiry, 1974–1977. In conducting hearings on the environmental impact of a Mackenzie Valley gas pipeline proposed by the Canadian Arctic Gas consortium, Commissioner Justice Berger heard extensive evidence on the value of wilderness, which he defined as a nonrenewable resource (Berger 1977: 30). Justice Berger concluded that the coastal portion of the proposed route was incompatible with the environment, including wildlife and the hunting, trapping and fishing activities of Native people. He argued for the protection of the resource base: "In the North, certain ecosystems and certain migratory populations can be protected and preserved only by recognizing the inviolability of wilderness." (Berger 1977: 31)

He therefore recommended the withdrawal of lands north of the Porcupine River for establishment as a national wilderness park:

> The wilderness park that I am proposing here would cover approximately the same area as the Canadian part of the proposed Arctic International Wildlife Range, and it would adjoin the 9 million acre Arctic National Wildlife Refuge in Alaska . . . . . Together, these two areas would constitute a magnificent area of 18 million acres spanning the international boundary. (Berger 1977: 48).

The significance of this proposal is further emphasized by Justice Berger's recognition of the need for a new type of "wilderness park." He noted explicitly that certain recreation and development-oriented activities usually associated with Canadian national parks are incompatible with the interests of wildlife protection. Berger thus suggested a revision to Canadian national parks legislation to include a new statutory creation, wilderness parks (Berger 1977).

On July 4, 1977 the National Energy Board (NEB), following the Berger Inquiry and results from their own hearings, rejected the Mackenzie Valley Gas Pipeline route proposed by Canadian Arctic Gas (Rees 1978). As an alternative they recommended the last minute proposal by Foothills Pipe Lines (Yukon) Limited whose route would follow the Alaska oil pipeline to the Alaska Highway and thence southeast to Alberta. Included in this proposal was a spur link called the Dempster Lateral which would eventually facilitate the transportation of Mackenzie Delta gas to southern markets. The Dempster routing would approximately parallel the Dempster Highway from Inuvik to Dawson, and continue southeast to the Alaska Highway Pipeline. Application for the Dempster Lateral must be submitted to the NEB by July 1, 1979 in conjunction with an environmental impact assessment of the pipeline.

Native Proposals

The pace of events increased through this period. The Committee for Original Peoples Entitlement (COPE), an organization representing the 2500 Inuvialuit (Inuit of the Western Arctic), presented its *Inuvialuit Nunangat* land claim settlement proposal to the Federal Government in May 1977. While this emphasized the protection of Arctic wildlife as a primary goal, creation of a specific wilderness park was not suggested.[1] COPE originally envisaged that wildlife habitat protection would fall under a Land Use Planning and Management Commission, which would be empowered to manage an area designated as the Western Arctic Region. Wilderness areas or wildlife preserves could then be set aside within this Region by the Commission (Committee for Original Peoples Entitlement 1977).

This "Western Arctic Region" overlaps with the proposed AIWR along the coastline, as well as with the lands identified for a land claim settlement by the Council for Yukon Indians. The Old Crow people, the only Native group living within the proposed AIWR, subsequently agreed upon a jurisdictional boundary to separate their traditional lands and those of the Inuvialuit under the COPE claim.

In February 1978, the Old Crow people, under the Council for Yukon Indians, submitted their proposal for much of the area in question to the Working Group on Parks and Scientific Preserves at a Canadian Arctic Resources Conference in Edmonton. This proposal included provision for an international wildlife range:

> We the residents of Old Crow do hereby resolve that:
> 1. The Government of Canada legislate and negotiate with the Government of the United States, an Arctic Wildlife Range in northeastern Alaska and northern Yukon;
> 2. That the birds and wildlife in the above areas are international in status and therefore require international protection.
> 3. That the above request will not include the Old Crow Flats area, as it is negotiable under the Yukon Indians Land Claims Package
>
> (Northern Transitions 1978: 251).

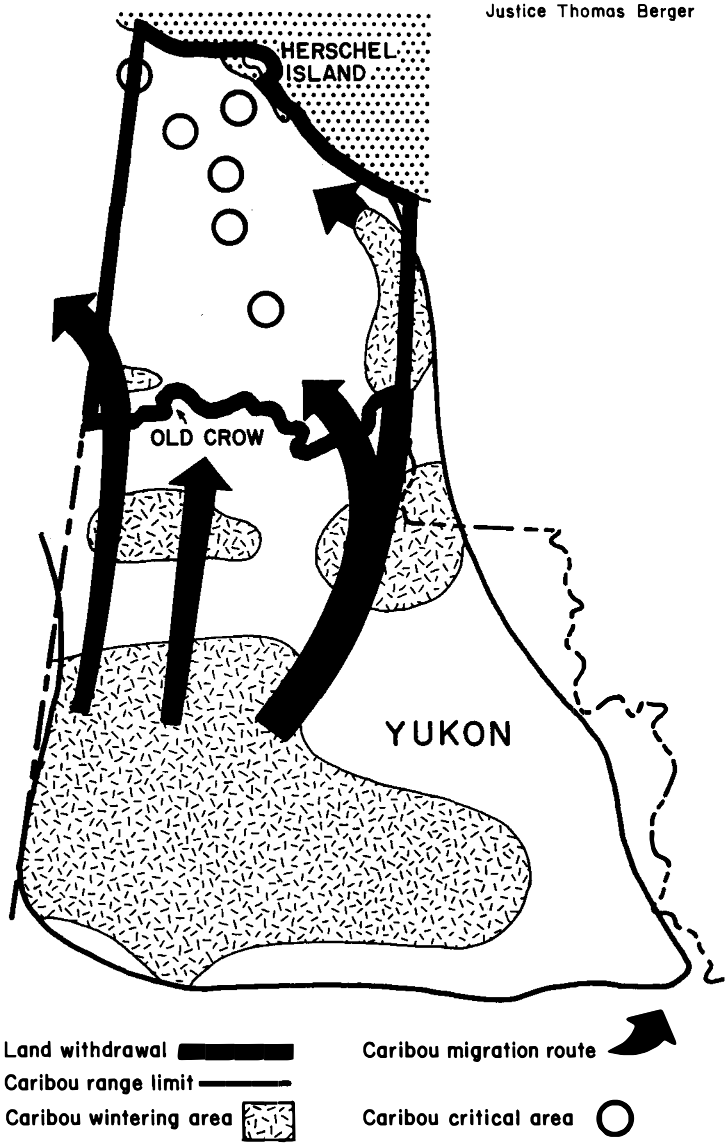
Government Studies and Task Forces

Meanwhile, various branches of the Federal Government initiated a confusing array of studies of the northern Yukon lands. Parks Canada commissioned the Lands Directorate to do an ecological land survey of the area north of the Porcupine and Bell Rivers, covering approximately 16,988 mi^2 (44,000 km^2). *The Northern Yukon: An Ecological Land Survey* was completed in August of 1978, and is available to the public. This survey was in response to the need for greater knowledge of an area identified in March 1977 by Parks Canada for a proposed National Park Reserve (DINA 1977, see Figure 1). Parks Canada's proposal covers about 8,200 mi^2 (21,238 km^2) with examples of major arctic landscapes, i.e. the Old Crow wetlands, the unglaciated British Mountains, the Firth River Valley,

[1]As noted in a later section, COPE, following on Justice Berger's recommendation, later proposed the creation of a National Wilderness Park.

Wilderness is a non-renewable resource...
...wilderness constitutes an important — perhaps an invaluable — part of modern-day life; its preservation is a contribution to, not a repudiation of, the civilization upon which we depend.

Justice Thomas Berger



(Northern Perspectives, Vol. VII. No. 2, 1979)

Figure 1. Area identified by Parks Canada for a proposed National Park Reserve, March 1977.

the Arctic coastal plains and offshore waters. Important habitats for waterfowl, barren-ground caribou, grizzly, black and polar bears, Dall's sheep, Arctic fox and hare, ringed seal, beluga whale and others are also included.

Dr. Art Pearson, Commissioner of the Yukon Territory felt that the proposed park would not provide adequate protection for the Porcupine Caribou. The Department of Indian and Northern Affairs therefore organized a Northern Yukon Conservation Planning Task Force.

> *The Task Force will:*
> *Identify* the manner in which a National Park and other conservation mechanisms could be established so that they could exist in the most complementary way in the context of other identified interests. (DINA 1978: Appendix I)

The Task Force's membership included representatives from the Northern Program, Office of Native Claims and Parks Canada (all agencies of DINA), Canadian Wildlife Service of the Department of the Environment, the Yukon Territorial Government and the U.S. Fish and Wildlife Service. The Task Force produced an internal report in 1978 which presented six options for the area north and west of the Porcupine, Bell and Rat Rivers (16,000 mi^2 or 41,440 km^2).

These are:

1. No action (status quo)
2. Special Land Management Zone under the Territorial Lands Act
3. Canadian Wildlife Area under the Canada Wildlife Act
4. National Wilderness Park using the National Parks Act
5. Combinations of (3) and (4)
6. Withdrawal under section 19 of the Territorial Lands Act, as an interim measure only

Each option was discussed according to its advantages and disadvantages in terms of flexibility (multiple use), ease of implementation, and level of preservation. Table 1 summarizes this analysis.

Significantly, the Task Force concluded that the settlement of Native land claims was an overriding consideration, and that the confusing variety of preservation interests and management decisions necessitated a conservation plan to provide a mechanism for coordinated and cooperative management. They there-

Table 1. Relative strengths and weaknesses of conservation options. Option 6 was not rated because it is regarded a temporary measure only (DINA, 1978).

Conservation option	[a]Rank in terms of: Flexibility	Ease of implementation	Preservation
No action	1	1	5
Special zone	2	3	4
Wildlife area	3	2	3[b]
Combination	4	4	2[b]
Wilderness park	5	5	1

[a]1 = greatest; 5 = least

[b]allows for a measure of conservation for the areas south of the Porcupine and Bell Rivers through a CWS/YTG agreement.

fore were unable to propose any ready-made solutions and instead, recommended the following to the Minister of Indian and Northern Affairs:

1. That the Northern Zone be withdrawn under Seciton (Sic) 19 of the Territorial Lands Act (Option 6) pending further study and consultation with the concerned parties. The wording of withdrawal Order-in-Council stipulate that:
   a. Such a withdrawal will not prejudice native land settlements; and
   b. Local people may continue to harvest renewable resources as they have done previously.
2. That the current efforts towards achieving a management plan for the Dempster Highway be accelerated and implemented by the Yukon and Northwest Territorial Governments. This is considered urgent.
3. That the Yukon Mineral Act be passed to enable control of mineral activities by means of the Territorial Lands Act.
4. That the Northwest Territorial Government be requested to prohibit the sale of game meat except if otherwise specified in Native Claims Settlements. This would not preclude intersettlement trade or barter.
5. That the Canadian Wildlife Service (DOE) be requested to negotiate a caribou research and conservation agreement with the agencies responsible for the management of the Porcupine Caribou herd with a view to achieving cohesive management (North Yukon Conservation Planning Task Force 1978).

Background information supplied by the Task Force report led to the Hon. Hugh Faulkner's announcement in January 1978 of the initiation of public consultation respecting six potential wilderness areas in the Arctic " . . . as reserves for future national parks" (DINA Communique #1–7792). The proposed package included the Northern Yukon as one of the six. On July 6, six months after this initiation, Mr. Faulkner announced the withdrawal of 9.6 million acres (3.87 million ha) of northern Yukon lands, between the Porcupine River and the Beaufort Sea, as an initial step towards establishing a northern national wilderness park.

> I have concluded that the conservation values of the region exceed the development potential and we must reserve all the land north of the Porcupine and Bell Rivers . . . . The action will not prejudice land claims discussions nor traditional native hunting, fishing and trapping activities in the area . . . .Existing mineral claims and oil and gas interests are not affected by the withdrawal, and exploration on such proterties (sic) may proceed under normal government regulatory controls. [However], the withdrawal stops further disposal of land under the Territorial Lands Act for oil and gas exploration, ends the sale or lease of surface rights, and prohibits entry for staking of mineral claims . . . (DINA Communique #7821 July 6, 1978).

The Minister also announced the establishment of a second Task Force to " . . .develop and recommend a comprehensive Resource Management Plan covering the Canadian range of the Porcupine Caribou Herd, including definition of boundary options for a National Wilderness Park" (DINA 1979). The Task Force is comprised of one representative each from: Government of the Yukon (Chairman); Government of the Northwest Territories; Department of Fisheries and Environment; Northern Program, DINA; Parks Canada, DINA; Committee for Original Peoples Entitlement; Council for Yukon Indians; Old Crow Community; communities of Fort McPherson, Arctic Red River and Aklavik; Yukon Chamber of Mines; oil and gas industry; and conservation organization under auspices of the Yukon Conservation Society. The Terms of Reference were internally drafted from November 1978 to January 1979, and were circulated to the participants. The study is underway and final recommendations are to be submitted to the Minister by December 1979.

Herman Dirschl, Executive Secretary of this Northern Yukon Task Force, has indicated that the Task Force would act as an umbrella organization to coordinate working groups on northern Yukon land use planning and management. For example, the Territorial Governments of Yukon and Northwest Territories have a joint Dempster Highway Working Group which has recently completed an Interim Plan for the management of the Dempster Highway; Parks Canada is continuing the public consultation program for a national wilderness park announced by Faulkner in January 1978; and under the COPE/Canadian Government Agreement-in-Principle, a National Wilderness Park Steering Committee has been established to make recommendations to the Minister by October of 1979 on the possible purpose, functions and management of the 5,000 square mile (approx. 13,000 km^2) (minimum) Wilderness Park.

There is considerable overlap between this last committee and the DINA Task Force in terms of membership and objectives. Indeed, in a March 6, 1979 letter to Minister Faulkner, COPE stated its feeling that the Task Force is encroaching upon the responsibilities of the Steering Committee regarding concerns inside the Wilderness Park:

> . . .the primary responsibility of the Steering Committee is to consider the area that is withdrawn including both the 5,000 sq. miles which is the minimum area to be dedicated as a National Wilderness Park and the additional 11,000 sq. miles which is recommended to be dedicated as the National Wilderness Park. We feel that it is not the responsibility of the Task Force . . . to review and evaluate options for the ultimate disposition of the withdrawn area particularly the 5,000 sq. miles.

Conflict may arise therefore when broad land allocations, including the delineation of wilderness park boundaries, are decided upon within the Steering Committee that are contrary to the other interests represented on the Northern Yukon Task Force. This, with other interdepartmental rivalries, may seriously hamper coordinated land use planning and management.

Caribou Convention

Concurrently on July 6, 1978, Environment Minister Len Marchand stated that the Canadian Wildlife Service (CWS) would open discussions with the U.S. Department of the Interior on a Canada/U.S. agreement on the protection of the Porcupine Caribou herd which migrates between the Yukon, NWT and Alaska.

> The central idea . . . is the need to manage the entire herd and its range, on both sides of the border, as an ecological unit. In other words, there needs to be a comprehensive approach, which means close and continuing cooperation between the various agencies responsible for caribou and its habitat in both countries (Environment Canada Press Release, July 6, 1978).

Accordingly, the Canadian Wildlife Service (CWS) organized a committee, headed by Mr. Anthony Keith, to draft an international convention. Representatives of the CWS and the U.S. Fish and Wildlife Service have met on several occasions to discuss basic concepts and to draft proposed conventions. The main concepts include (compiled from American and Canadian drafts):

–long-term conservation and management of the caribou and the ecosystem of which they are part
–establishment of a flexible management model based on the principles that:
 –consumptive and nonconsumptive values are optimized on a continuing basis;
 –present and future options are to be ensured;
 –risk of irreversible change or long-term adverse impact is to be minimized;
 –subsistence use of the caribou must have priority over any other consumptive use
–a ten-member Migratory Caribou Commission would be established, five from each country. A scientific advisory committee and an advisory committee of traditional subsistence users would be established by the Commission for direct assistance in the performance of its duties;
–the powers and duties of the Commission include:
 –recommendations on measures for harvest quota allotment including establishment of maximum allowable take (total numbers and per country), taking seasons, methods, etc.;
 –recommendations on measures to ensure conservation and enhancement of caribou habitat, including long-term measures;
 –coordinated research is encouraged;
 –public participation on the Commission's annual reports and recommendations.

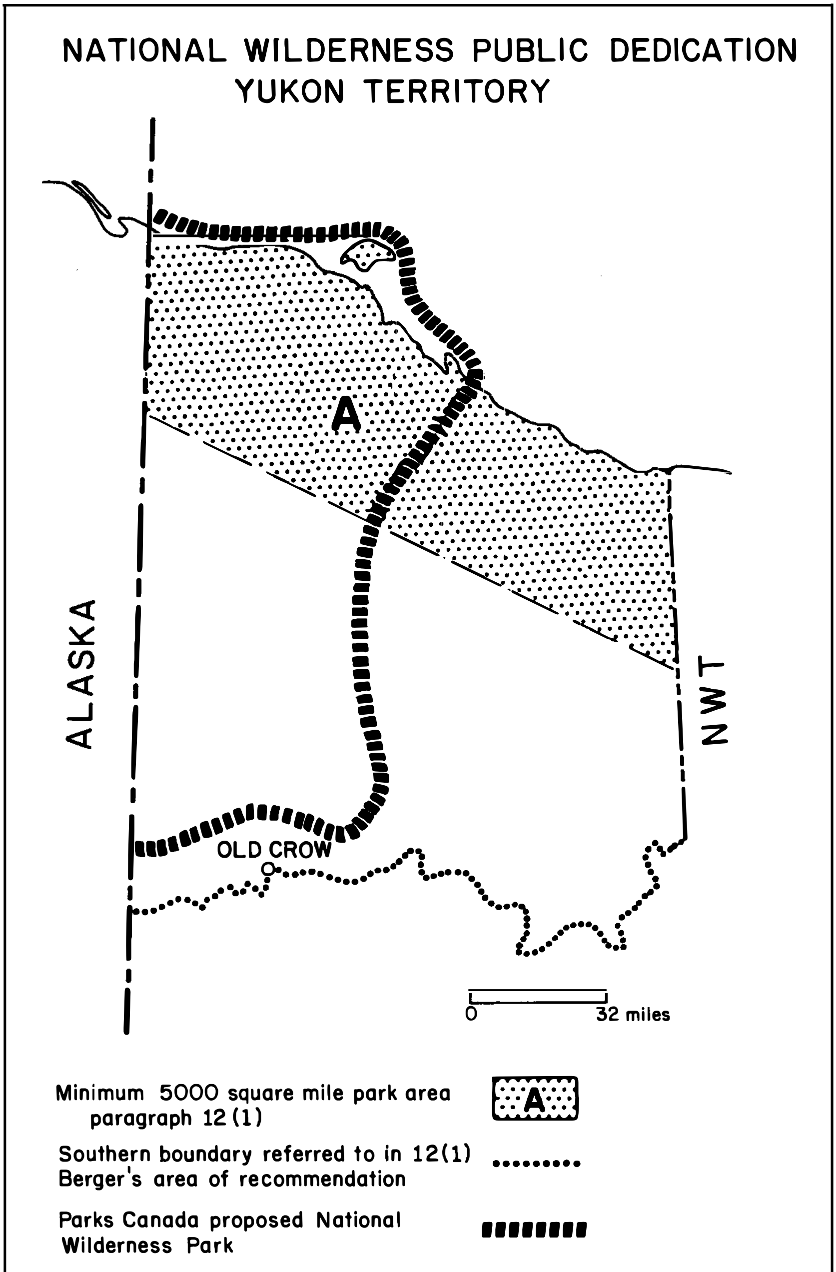
COPE/Federal Government Agreement-in-principle

The Inuvialuit Land Rights Settlement is also of significance in this context. On October 31, 1978, COPE and the Federal Government signed an Agreement-in Principle on the COPE claim. Regarding the northern Yukon's potential as a wilderness reserve, the Agreement states in Section 12 that as a minimal agreement:

> 12 (1) Canada agrees to establish a National Wilderness Park for the purpose of wildlife protection and wilderness conservation of not less than 5000 square miles of traditional lands of the Inuvialuit in the northern Yukon shown as the area marked "A" in Annex E and in pursuance thereof has withdrawn from disposal under the *Territorial Lands Act* certain lands therein as described in the *Prohibition and Withdrawal of Certain Lands from Disposal Order, 1978* SOR/78 - 568, 6 July 1978. (See Figure 2)

However the agreement recommends that the government actually withdraw the much larger area north of the Porcupine River for this purpose as outlined by Berger (1977). As previously noted, this deviates from the original COPE proposal that called for a Land Use Planning and Management Commission which had authority to set aside wilderness areas or wildlife reserves.

It should be noted that at present there is no legal basis for "National Wilderness Parks" in Canada. While discussion is underway concerning possible policy for such reserves in future, it is currently uncertain, given the strong development orientation historically of Parks Canada (Turner and Rees 1973), whether a National Wilderness Park or other form of conservation reserve would best serve the multiple objectives of society in the disputed lands of the northern Yukon.



(Inuvialuit Land Rights Settlement, Agreement-in-Principle, 1978)

Figure 2. National Wilderness Public Dedication, Yukon Territory.

Additional Proposals

Several other proposals for the preservation of northern Yukon lands have also been promulgated. There are six proposed Ecological Reserves of the International Biological Programme—Panel 9: Site 4–1 (Canoe Lake, Richardson Mountains); 4–7 (Herschel Island); and 4–10 (Firth River), (Nettleship and Smith 1975) and Panel 10: Site 5 (Old Crow Basin); Site 6 (Firth River—larger than Site 4–10); and Site 7 (Rat River, Yukon/NWT Border) (Beckel 1975). The National Museum of Canada has great interest in the rich and internationally significant archaeological and palaeontological resources in the northwest area of the Yukon. Current research is being carried out by Dr. Richard Morlan for the National Museum of Man under the "Northern Yukon Refugium Project," and by Dr. William Irving under a Parks Canada contract in the Old Crow Flats area (Morlan 1978). Discussion within several federal agencies also continues on the possibility of a joint submission by Canada and the U.S. to the United Nations Educational, Scientific and Cultural Organization World Heritage List, to cover the ANWR and the lands within the withdrawn area.

Meanwhile, private environmental organizations from Canada and the U.S. held a special strategy meeting in Whitehorse on March 16–18. Representatives of the Yukon Conservation Society, the Alaska Conservation Society, the Canadian Arctic Resources Committee, the Canadian Nature Federation, the Sierra Club of Western Canada, and the Arctic International Wildlife Range Society agreed to form a united front to support a comprehensive approach to conservation and development for northern Yukon lands and resources. To carry this forward, the Arctic International Wildlife Range Society will be revitalized. The resolutions stemming from the Whitehorse meeting represent a firm commitment to comprehensive planning and management.

BE IT RESOLVED THAT:

1. We strongly endorse the speedy completion of the international convention between Canada and the United States for the conservation of migratory caribou and their environment.
2. Under the umbrella of this convention there be established a unified regime of land management, habitat management and species management to ensure the accomplishment of the principles stated above for the entire range of the Porcupine Caribou Herd in Alaska, Yukon and Northwest Territories.
3. This management regime must provide for certain restraints that are basic to the primary objective of conservation of the herd, its habitat and the ecosystem of which it is part. These are:
   (a) that subsistence harvesting of any species be given priority within the sustaining capacity of the ecosystem;
   (b) that any other use of the region must not be prejudicial to the primary objective; and the onus of establishing that a particular use is not prejudicial must rest on the potential user.
4. Within the withdrawn portion of the region and the adjacent portion of the caribou range in the Northwest Territories we support a national park of a wilderness character, a national wildlife area, or a combination of these, following appropriate agreements with native peoples but only if the legislation establishing such a national wilderness park or national wildlife area fulfill the principles stated above.

Conclusion

The various overlapping and/or conflicting proposals for much of the northern Yukon suggest that some form of permanent conservation status for at least part of the area is likely. Cooperation between Canada and the U.S. on planning and mangement policies for the Porcupine Caribou and their habitat is of course a central issue, and essential to the success of any future reserve. Although current conflict and debate focuses on the withdrawn lands, management of the entire range in conjunction with the Arctic National Wildlife Refuge must be emphasized in order to realize the comprehensive scope outlined by Marchand in July, 1978.

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Is Arctic Offshore Drilling for the Birds: Some Technical and Policy Concerns of Environmentalists

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Introduction

You who . . . the High North is luring
Honor her . . . ever and ever,
Whether she crown you, or whether she slay;
Suffer her fury, cherish and love her—
He who would rule must learn to obey.

Robert W. Service

As we all know, the potential for oil and gas production from Arctic resources is alluringly enormous. And most of us have some grasp of the environmental hazards hydrocarbon production presents in the North.[1] Yet no responsible environmental group advocates locking up these resources. That is a silly notion put forth by others to discredit a serious and legitimate concern for the ecology of a highly sensitive region. Most environmentalists know that some development will occur, and most probably believe that it should.

But we also know that the region contains resources that must be protected as well as those that should be developed. We know, too, that the pace and style of development will have a concomitantly enormous impact on the northern environment and on the lives of northerners, and that the spin-offs from resource extraction will affect not only northerners, but all Canadians, and even the international community.

If used wisely, the resources of the High Arctic can provide benefits to northerners and southerners alike. Finding ways of ensuring that these resources will be used wisely is a challenging task. It is this task—ensuring that ecological considerations will be justly weighed in making decisions about development—that environmentalists are most concerned about. And it is with some of the problems encountered in assuming this task—specifically with respect to offshore drilling—that I am concerned today.

In discussing this issue, I will deal first with the scope and implications of Arctic offshore drilling. I will then examine some of the shortcomings of government policy and decision making in this area. Finally, because a technological fixation

[1]Two documents provide an overview of the environmental aspects of offshore hydrocarbon exploration and development:
a. Berger, Thomas R. *Northern Frontier, Northern Homeland,* Volume I, 1977. Dept. of Supply and Services Canada. Pg. 67–75.
b. Baker, Robert. *A Study of Environmental Concerns: Offshore Oil and Gas Drilling and Production,* 1978. Fisheries and Environment Canada, EPS Report 2-EC-78-1.

plays an important role in the inability to overcome these shortcomings, I would like to shed a bit of light on some aspects of offshore drilling engineering by offering a brief overview of what might be called an introduction to drilling safety.

The Scope

Experience with large-scale development in the south has amply demonstrated its cumulative effects on the physical, social, and economic features of the environment, and the interdependence of these on one another. Once begun, even the most well-studied and supposedly limited projects have a way of unpredictably affecting other environmental systems, as well as of growing in their own right. In fact, whether laying out a new transit network or a new subdivision, this multiplier effect is precisely what planners and developers count on and, to the best of their ability, prepare for, although they are not always sanguine about foretelling the exact course growth will take.

Yet because news about Arctic resource development tends to focus on individual projects—on the construction or financing of one pipeline, of one type of tanker, or of one highway—it is difficult to envisage the overall impact of development now underway or under consideration for the future. This is perfectly understandable. The region is vast and sparsely populated. And not only is the northern context far less familiar than the southern, but the government requires that applications for permission to proceed be made, examined, and decided on a single-project or a single-phase basis.

As a consequence, it is extremely easy to lose sight of the breadth, as well as the implications of Arctic development. Before turning to the implications, therefore, it would be wise to review the international scope of resource extraction activity, keeping in mind that the Arctic environment has little regard for political boundaries. Looking from east to west at the six major regions, three of which are in Canada, where both on- and offshore exploration and development are now occurring we have the following situations.

In the first region, northern Russia, despite relatively limited exploration, substantial onshore gas and oil reserves are being developed within the Arctic Circle. Reserves have also been discovered adjacent to the Kara Sea, suggesting that offshore activity may be in the offing. Russia's reserves appear to be sizable. Urengoy, for instance, a gas field with an areal extent just slightly greater than some of the Canadian Beaufort Sea geological structures, has an estimated reserve of 210 trillion cubic feet (5.9 trillion m^3)—enough to meet Canada's present annual demand for about 140 years.

In the second region, Alaska, there is, of course, the Prudhoe Bay onshore oil and gas field, discovered in 1968. There, proven reserves amount to 9.6 billion barrels of oil and 26 trillion cubic feet (728 billion m^3) of gas. Only the oil is presently being marketed, although a gas pipeline should be operating by 1984 or 1985.

Alaskan offshore development is also underway. In October 1978, Exxon began drilling at a site 12 miles (19 km) east of Prudhoe Bay in the Beaufort Sea. Fearing that it could adversely affect caribou migrations and further endanger the bowhead whale, Native communities filed suit in both state and federal courts to stop the drilling. The Alaska Department of Environmental Conservation is supporting the Native people because the U.S. Army Corps of Engineers apparently violated the Federal Water Pollution Control Act when it issued permits to Exxon. A preliminary injunction has been denied with the courts ruling that, while harm could be done to both sides, the greater damage, were drilling to be stopped, would accrue to Exxon. Obviously, this refers solely to financial damage. A trial on the merits is pending based on the procedural violations, the National Environmental Policy Act and the Endangered Species Act. This all has onerous implications for the Joint Federal/State Beaufort Sea offshore oil lease sale scheduled for December 1979.

In the third region, the Mackenzie Delta/Beaufort Sea area, dredged material has been used to construct 15 artificial islands in shallow water from which a modified form of land drilling can be done. Deep-water drilling was begun by Dome–Canmar in 1976 using specially strengthened drill ships. From these, nine wells have been spudded, four of which have been discoveries, two subject to further drilling, and three abandoned for technical reasons. The deep-water drilling operation has encountered a series of unanticipated technical problems, including several fresh water blowouts and ice damage to two icebreaking support vessels that resulted in fuel oil spills. Nonetheless, Dome–Canmar is counting on moving oil and gas to southern markets via tanker by 1985.

The operator in the fourth region, the Arctic Islands, is Panarctic, a consortium in which Petro-Canada is the largest shareholder. Some 144 exploratory wells have been drilled, 13 of them offshore, netting one oil and seven gas fields. Thus far 12.8 trillion cubic feet (360 billion m^3) of gas has been discovered (about half the proven amount in the Prudhoe Bay field). Although those reserves are insufficient to warrant a pipeline, a consortium of companies (including Petro-Canada and TransCanada PipeLines) have formed Polar Gas to investigate a pipeline to the south.

Changes are afoot in the routing of the Polar Gas pipeline. Originating in Melville Island, it was initially to have run from island to island, to the mainland, and then south along the west coast of Hudson Bay. This was later changed to enable the pipeline to link up with the line carrying Mackenzie Delta gas by running it to the coast and then southeast along the edge of the Canadian Shield, creating a Y-shaped route. Most recently a proposal was put forward to run the line southwest, and then—amazingly enough—down the Mackenzie Valley!

In the fifth region, Canada's eastern Arctic, the Davis Strait, Lancaster Sound, and North Baffin Bay are each attracting attention from the oil and gas industry. In the first, Imperial Oil, Aquitaine, and others will begin this year to drill six holes off the southeast end of Baffin Island. Lancaster Sound, at the north end of Baffin Bay Island, has oil and gas acreage belonging to a consortium (including British Petroleum, the Canadian Development Corporation and Brascan) that has an agreement for drilling with Norlands Petroleum. After public hearings last fall, an environmental panel has recommended against drilling at this time (Environmental Assessment and Review Office 1979). The government concurred with this recommendation. That should act as a signal to Petrocan which is currently preparing an application to drill nearby in north Baffin Bay.

Greenland's portion of the Davis Strait is the sixth and final region. After two seasons of offshore drilling and five holes, little if anything, has been discovered. Further work is not being contemplated at this time.

The Implications

In short, virtually the entire circumpolar region is currently being considered for its resource development potential, and exploratory and extractive drilling are already extensive. But when we are looking at drilling, we are looking at what is simply the first stage in an inevitably snowballing development process. Drilling itself will require offshore production wells and structures, seabed production lines, onshore storage facilities and processing plants. To get the products out, pipelines will be laid and ports built. An extensive and entirely new infrastructure will be necessary, as will new modes of transport. Not surprisingly, the new transport-related technology is already forging ahead.

Dome is looking into construction of a Class Ten icebreaker— a vessel capable of moving continuously through 10 feet (3m) of ice at a minimum of 3 knots per hour. The icebreaker will be at least twice as large as any now operating, and will make year-round shipping feasible throughout the Arctic.

In January of this year, Petro-Canada, in partnership with AGTL, sought permission from the National Energy Board for their Arctic Pilot Project that will utilize two new Class Seven icebreakers to transport liquified natural gas from the Arctic Islands to the Maritimes or Quebec. The Canadian Coast Guard recently awarded a $6 million contract for the design of a Class Ten icebreaker. It is also expanding its icebreaking fleet with two new vessels costing over $100 million.

A recent study for the U.S. Maritime Administration, (Levine and Winall 1978) envisages a system of 10 tankers carrying oil from Alaska's North Slope to the eastern U.S. coast with trans-shipment in Greenland or Newfoundland. The report demonstrates that the United States has commercial interests as well as defense concerns in the Northwest Passage and the Canadian Arctic archipelago—compounding the reasons for the ongoing jurisdictional dispute over northern waters.

Of course, once tankers and icebreakers frequent the Arctic, not only marine ports, but airports and communications facilities will be expanded. Workers to service all these facilities will pour into the region. Existing towns will grow and new ones will be built.

Furthermore, northern development is unlikely to stop with oil and gas. Mining will undoubtedly follow once the region is made accessible by the pioneer industries. Southerners will benefit as the recipients of the extracted resources, as investors in the ventures and requisite new technologies, and as employees in their development, manufacture, and construction.

And so the process of growth will continue. The impact on all aspects of the environment will escalate. The likelihood of "unanticipated technical difficulties," such as those encountered by Dome-Canmar, will increase. Clearly, the multiplier effect works as inexorably in remote or isolated areas as in urban ones. Applications to undertake exploratory drilling, and a seemingly modest transportation proposal like the Arctic Pilot Project, are but the tip of an enormous iceberg.

Shortcomings in the Approach

Despite this readily apparent phenomenon, federal policies, particularly as they relate to environmental (and social) impact assessment, do not consider the long-term effects of *development.* Beset by titanic myopia, both government and industry blithly ignore the crucial fact that should exploration prove successful, the impact of drilling will expand exponentially. Each application is considered without regard to the impact spin-offs that will inevitably follow. Instead, the focus is on technical matters. One gets the impression that those who are charged with making assessments assume that no hydrocarbons will be found—or that if they are, we can best cross that bridge when we come to it.

This is patently absurd. Just because the environmental intervention is primarily technological at the outset certainly does not mean that its effects will be exclusively technological. Furthermore, no application is made with only the immediate prospect in mind. No industry is that shortsighted. Exploration is an exceedingly costly business. The willingness—or should I say rush—to undertake it is predicated on the expectation of eventual success, and of significant returns from the greatly expanded development that will follow.

There is no denying that piecemeal review of the sort now practiced has a certain procedural logic to it. Obviously it would be as difficult to demand a full-scale review of the effects on the entire Arctic from a single application to undertake exploratory drilling as it would be to review the entire impact on Toronto of constructing a single subdivision in Etobicoke.

But there are two significant differences between these examples. First, in urban areas the planning process is balanced so that no final decision is made by a single agency. By the time approval is obtained, a proposal and its ramifications have been thoroughly investigated by at least three levels of government with direct jurisdictional responsibility. These checks and balances of responsible government are lacking in the north. The Inuit communities and the territorial government remain outside the process.

Secondly, in the south, the impact and problems of subdivisions (or whatever) are sufficiently well known from previous ventures that a failure to undertake exhaustive studies in one instance can be compensated for by the weight of past experience. In the north, this experience is lacking. We are dealing with virgin territory, new technologies, and unknown effects. And information on the biological processes and resources of the north is embarassingly sparse.

This very ignorance makes it imperative that examination of any application extend beyond its immediate and specific effects. Instead, *de facto* planning decisions are being made for whole regions of the north on the basis of hurried examinations of exploratory drilling programs. There seems to be little concern for the irreversibility of the effects of development, as though what has been inherited will prevail no matter what we choose to do. Our arrogance in the north is exceeded only by our ignorance.

Now, I fully realize that I am not the first to see the need for a more carefully considered assessment process. On the contrary, Native organizations, public interest groups, international agencies, and some government officials have been making much the same case for quite some time. And in many respects, these groups have had a substantial and beneficial effect.

There can be no doubt that their efforts have made public concern for the impact of resource development far more widespread than it could otherwise have been. Nor can there be any doubt that their efforts have pressured the government into establishing a variety of mechanisms to investigate, limit, and mitigate these impacts.

As a result, the basic cultural, social, economic, and environmental conflicts to which northern development gives rise have become more familiar. It is now understood that decisions about the north must successfully reconcile the needs of those who have occupied, ruled, and obeyed the north for thousands of years, and for whom it is a homeland, with the needs of those for whom it is a frontier of untapped wealth. It is understood that the decisions being made involve weighing short-term profits against long-term costs.

Unfortunately, our current understanding, despite being greater than formerly, has thus far been insufficient to resolve these conflicts. This is manifest in the refusal of the federal environmental assessment panels to review long-term impacts. It is also manifest in the contradictions between different government policies.

On the one hand, land claim negotiations and the stated priorities of CANADA'S NORTH, 1970–1980, clearly place human and environmental values before industrial values. The strategy for the 70s begins by saying: "Government seeks a deliberately phased blending of social and economic programs which shifts emphasis and financial allocations to meet circumstances such as: Imbalance perceived in the approach to development at any time; disturbance caused by some external development . . . " (Department of Indian and Northern Affairs 1972:27)

On the other hand, as an aspect of its national energy strategy, the government has what is commonly (and ironically) referred to as the "need to know policy." Articulated in 1976, its aim is: "To double, at a minimum, exploration and development activity in the frontier regions of Canada over the next three years, under acceptable social and environmental conditions." (Department of Energy, Mines and Resources 1976:25)

To realize this goal, the government offers an attractive tax incentive. Its attractiveness is summed up by J. H. G. Roche (1978: 18), an oil and gas expert:

> It is somewhat surprising to note that to the extent that a taxpayer expends funds which qualify for the frontier exploration base, he will be earning deductions from income equivalent to 200% of the expense incurred. The deductions will be comprised of 100% for Canadian exploration expense, 33 ⅓% for ordinary earned depletion, and 66 ⅔% for frontier depletion.

"This," adds Roche, "must be viewed as an extremely strong incentive." It means that the cost of Arctic offshore drilling operations is subsidized completely by the government. It is not quite the corporate risk that we are led to believe.

Nor is that all. The government has also announced plans for a three-year holiday on the progressive incremental royalty (40 percent tax on profits) for discoveries made in the frontier region prior to 30 October 1982.

The need to know policy is couched in terms of the "national interest." But it is "national" only insofar as it refers to the national need for oil. To this interest it subordinates Native, environmental, and regional interests—any one of which can be seen as serving the national interest in its own right.

In addition, the policy misleadingly implies that once oil or gas is located, subsequent decisions regarding its development will naturally be wisely made. Experience shows that this is not the case. Canada has been searching with increasing urgency—some would say desperation—for energy resources. The limited potential of western gas and oil reserves, rapidly escalating costs, and the long delay in developing tar sand oil provide the basis for the government's encouragement of immediate Arctic exploration, particularly in its offshore areas. And once marketable hydrocarbons are found, there will be an irresistible and virtually uncontrollable rush to exploit them.

It is becoming increasingly evident that unless fundamental social and environmental concerns are raised and resolved prior to permitting exploratory activity, they will at best take second place to financial and technical considerations. In other words, contrary to the implications of the need to know policy, ecological considerations are more likely to be given short shrift than to be justly weighed in the decision-making process.

Understanding the Technological Aspect

Deciding whether drilling should proceed on the basis of financial and sheer technical feasibility is much like deciding whether to run an eight-lane expressway down Yonge Street on the same basis. Ludicrous as the analogy may seem, it isn't far from the reality—at least with respect to drilling. At the same time, however, if environmentalists are to responsibly contribute to decisions about the desirability and location of, say, highways, subdivisions, or airports, it is obviously necessary for them to firmly grasp the technical aspects of the respective risks and requirements of the facilities.

Naturally, familiarity with offshore drilling risks and requirements is equally important. Yet in my experience, environmentalists display a tendency to shy away from the technical data, believing, one must suppose, that it is too complicated, or that it is being adequately dealt with by experts. A crash course on northern offshore drilling will not entirely dispel these attitudes—it *is,* in fact, a complex subject—but such a review will, I hope, provide a basis for looking critically at what the experts say.

Basically, there are three areas of technical concern peculiar to northern offshore drilling: ice, spills, and the blowout. Ice itself is not a major ecological concern, but it turns the sea into a hazardous obstacle course, making it necessary to modify conventional drill ships and platforms, and to work on a seasonal basis. Dome, for example, uses specially reinforced vessels suitable for the ice-infested summer conditions of the Beaufort Sea. In winter, the moving ice prohibits drilling with current technology. Panarctic, by contrast, does all its offshore drilling in the winter, using the relatively stable winter ice adjacent to the Arctic Islands as a platform; in the summer, of course, their "platform" melts.

Spills in themselves, are not unique to northern waters. But because existing technology can contain and clean only minor spills, and these only in harbors or other areas where equipment is readily available and where there is protection from the winds and tides of the open sea, the threat of Arctic spills is particularly fearsome. As Prime Minister Trudeau said as far back as 1970 (Canada House of Commons 1970), when Parliament passed the Arctic Waters Pollution Prevention Act:

> The Arctic ice pack has been described as the most significant surface area of the globe, for it controls the temperature of much of the Northern Hemisphere. Its continued existence in unspoiled form is vital to all mankind. The single most imminent threat to the Arctic at this time is the threat of a large oil

> spill . . . (which) . . . would destroy effectively the primary source of food for Eskimos and carnivorous wildlife throughout an area of thousands of square miles . . . Because of the minute rate of hydrocarbon decomposition in frigid area, the presence of any such oil must be regarded as permanent. The disastrous consequences which its presence would have on marine plankton, upon the process of oxygenation in Arctic North America, and upon other natural and vital processes of the biosphere, are incalculable in their extent.

Astonishingly, little has been done to resolve these issues over the past decade. They are even more urgent now. While really major spills are likely to result from blowouts—to which I will return momentarily—accidents to storage, docking, and offshore production facilities, to tankers, and to subsea pipelines could also cause substantial environmental damage. And, of course, the Arctic's ice conditions increase the likelihood of accidents. However, as the government's Arctic Marine Oilspill Program (1978:1) points out, environmental damage is not the sole problem with spills:

> . . . an oil blowout could go unchecked for one or two years, discharging tens or hundreds of thousands of tons of oil into Arctic waters with serious long term effects on the environment, on negotiations with native people over land claims, and on the credibility of Canada vis-à-vis its claims of sovereign rights to protect the Arctic environment in the Canadian sector.

Blowouts tend to dominate the environmental debate as it is currently conducted. While this distracts attention from the fact that in the broader environmental context, the harm from development as a whole may be more pernicious than the damage caused by a single catastrophic event, the genuine hazards of blowouts cannot be ignored.

Blowouts occur when drillers lose control of a well, allowing gas or oil to escape uncontrollably up the drillhole to the surface. When a blowout occurs, attempts to control and clean up the spill are important, but the ability and time required to "kill" or stop the blowout is even more important if an environmental tragedy is to be averted. Control must be regained over the existing hole, or a second must be drilled to intercept the pressurized hydrocarbon flow. But the drilling rig may have been damaged or destroyed during the blowout rendering it useless for drilling a relief well. Ice-infested waters and weather can pose substantial delays. And although government regulations require a same-season relief well capability, a late-season blowout could go unchecked until the onset of the next drilling season.

Preventive measures are built into the drilling system to minimize the risk of blowouts. Normally, the drilling mud in wells exerts enough pressure to prevent formation fluids (gas, oil, or water) from flowing back into the well. But if the drilling bit penetrates a zone containing fluid under abnormal pressure, the weight of the mud may be insufficient to counterbalance the fluid's upward pressure. Drillers call this "kicking," and unless the crew can rapidly increase the weight of the mud system, there is a chance that they will lose control of the well, and formation fluids will shoot to the surface.

Hence, drilling mud is the first line of defense against blowouts. Drilling operators are required by government regulation to ensure that the mud employed is of the correct density. Continuous monitoring of formation pore pressure, penetration of hydrocarbon bearing horizons, water bearing strata, and other potentially hazardous formations is also required.

The second line of defense is an assembly of valves known as the blowout preventor, or BOP stack. The BOP, which rests on the seafloor, is connected to the drilling rig by a pipe called the marine riser, which serves as a conduit for drilling mud and cuttings that are circulated to the surface. The valves in the BOP stack are designed so as to hermetically seal the well when necessary. In case of emergency, one valve can shear off a pipe and close-in the hole.

The third line of defense is the casing pipe that is cemented against the wall of the upper portions of the hole before drilling into deeper formations. Casing design criteria in Canada is considered to be one of the safest used anywhere in the world. Elaborate function-and-pressure testing for all control equipment, including BOP systems and casings, are tightly regulated. Conditions and pressure limitations are constantly monitored, and drilling operations modified to adapt to changing specifications or pressure ratings.

These measures make the chances of a polluting blowout incident from geological or engineering causes remote. Many people in industry and government are fond of saying that they reduce the risk to one in a million. That is very misleading.

The Issue of Risk

A rigorous analysis of Arctic blowout probabilities was recently done for the Environmental Protection Service of Environment Canada by F. G. Bercha and Associates of Calgary (1978). The study concentrated on South Beaufort Sea conditions and examined drilling from both artificial islands and drillships.[2]

Bercha notes that by far the greatest cause of drillship blowouts is operator error—accounting for 73 percent of all incidents. Equipment failure accounts for 15 percent, inadequate engineering and catastrophes for 6 percent each.

Table 1 summarizes Bercha's best estimates of blowout probabilities.

As can be seen, the chance of a major oil blowout (for example, of about 5,000 barrels per day), is close to one in a million for drilling operations from artificial islands, but is about four times that for drilling from ships. Smaller blowouts (for example, of 50 to 500 barrels per day) have a probability of up to 3 in 10,000. Quite apart from the possibility of these "smaller" blowouts doing major environmental damage, a closer examination reveals that within what statisticians call their 90 percent confidence interval, the figures could vary from 20 to 200 percent. Furthermore, the values used are based on the combined figures from drilling in "normal" geological areas and in those containing high pressure hydrocarbons. To obtain "normal" values alone, the figures must be divided by 1.2; to obtain values for high pressure areas alone, they must be multiplied by 4.

It should also be noted that these figures are not based on experience with existing wells operating under various conditions. They are based entirely on a mathematical modelling of a drilling operation.[3] In the most crucial area, operator error, no industry data is available at all.

[2]A second study by Bercha entitled, *Exploratory Drilling Blowout Risk in Davis Strait* was prepared for the Department of Indian and Northern Affairs in January 1979. (unavailable at time of writing)

[3]The merits and pitfalls in Bercha's methodology are currently being investigated by the Canadian Arctic Resources Committee.

Table 1. Summary of best estimates of blowout probabilities (Bercha and Associates 1978).

Type of blowout event	Probability of event — System and condition: Island summer	Island winter	Drillship summer	Weighted average
(1) Blowout (Any kind)	0.577×10^{-3}	0.652×10^{-3}	2.41×10^{-3}	1.51×10^{-3}
(2) Blowout ($Q \sim 50$ bbl./day)	0.721×10^{-4}	0.814×10^{-4}	3.02×10^{-4}	1.89×10^{-4}
(3) Blowout ($Q \sim 500$ bbl./day)	1.76×10^{-5}	1.99×10^{-5}	7.36×10^{-5}	4.62×10^{-5}
(4) Blowout ($Q \sim 5{,}000$ bbl./day)	0.880×10^{-6}	0.994×10^{-6}	3.68×10^{-6}	2.31×10^{-6}

In projecting blowout probabilities for numerous wells over a period of years, Bercha concludes that in drilling 100 offshore wells per year for 10 years (1,000 wells) from *both* artificial islands and drillships, there is a 37 percent chance of a blowout of some kind, a 16 percent chance of a hydrocarbon blowout, a 4.4 percent chance of an oil blowout of some size, and a chance of a major oil blowout in the order of one quarter of one percent. Small, but not one in a million.

These are not exactly comforting figures. But even more discomforting is what the raw and naked data omit: the high probability of spills if development were to proceed and the replacement cost of what would be lost should a spill occur. Clearly there is no way statistics could reveal what is essentially incalculable. Yet it is primarily on the basis of selective statistics (many of them distorted or downright inaccurate), that decisions are being made about whether drilling should proceed.

Look at it this way: the chances of holding the winning ticket in a major million-dollar lottery are but one in a million; but the cost of the ticket—five dollars or so—is insignificant if you lose. Now suppose the chances of coming out a dead loser in a game of Russian roulette were also one in a million; here the rewards might be great, but the cost of losing is rather severe. In the north, we are now playing Russian roulette. I would contend that if anything is to survive in the Arctic other than just the odds of a preliminary hazard—exploratory drilling—must be considered in a rigorous way.

Conclusion

In much of the north, development can undoubtedly proceed if done in a careful and controlled fashion. But in some areas, natural attributes preclude development of any kind. In such places, we must choose between immediate financial gain, and the very survival of an unspoiled and natural system. We have inherited priceless areas, and we bear the responsibility for passing them on to future generations.

The future of Canada does not rest on one pool of oil, and places of biological importance in the North should be the very last places in which we flex our technological muscle, not the first. The embryonic condition of the technology of

Arctic oil and gas exploration, development and transportation makes it imperative that we learn to look before we leap. Our task is to ensure that in considering drilling proposals, a number of basic questions are posed at the outset. We must know, for example, whether an area can sustain major hydrocarbon production with its wells, pipelines, tankers, people, and so on. Only then can a fair decision be made about beginning exploration.

In summary, I would like to reiterate just three points:

First, offshore drilling cannot and must not be considered in isolation from the massive development that will inevitably follow.

Second, a means must be found and implemented to ensure that the larger implications of Arctic exploration and development will be examined and fairly weighed in the decision-making process from the outset. This is particularly important from the circumpolar perspective where actions of one nation will affect another. An immediate objective would be to establish international standards for Arctic offshore projects.

Third, at no stage should the debate about development be permitted to focus exclusively on technology. At the same time, because large-scale and new technologies are a major feature of northern resource development, and because they will be responsible for major aspects of that development's impact on the North, they must be fully understood by environmentalists.

I began this talk with Robert Service's dire observations on the discipline that the north imposes. Let me conclude with Rachel Carson's view of what lies at the heart of all environmental decisions: "We in this generation must come to terms with nature . . . We are challenged as mankind has never been challenged before to prove our maturity and mastery, not of nature, but of ourselves."

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Canada's Decision to Deliver Western Arctic Natural Gas

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Alaska Highway Pipeline Panel, Winnipeg, Manitoba

All of you are involved in impact assessment in one way or another, so it is not my intention to try to tell you how to make impact assessments. What I would like to talk about is the place that impact assessments have in the decision-making process. Then I'll go through the various "sub-decisions" that were made which led to the Canadian decision regarding whether to build a pipeline from Prudhoe Bay, Alaska through Canada to the southern 48, and if so, what route should be used.

First to set the stage: in Canada's Mackenzie Delta, there were some reserves of natural gas; not large ones to justify a line alone but useful to piggyback onto the Prudhoe Bay line. So, two applicants came forward with the idea that they would construct a pipeline from Prudhoe Bay, picking up the Mackenzie Delta gas and running along the Mackenzie River to Alberta. There the Canadian gas would be taken off, and the American gas from Prudhoe Bay would continue on to the southern 48.

Canada does not have an Environmental Protection Act but it subjects some projects to environmental and/or socioeconomic reviews. The pipeline project was selected for review of both environmental and socio-economic issues. And, since it would be a utility, the National Energy Board was required to review it for engineering and economic feasibility. If the pipeline met the standards of that review, the Board would issue a Certificate of Public Convenience and Necessity.

In the environmental field, the concerns were first seen to be components of the environment such as the Porcupine caribou herd, fish, birds, vegetation and permafrost. Later on, combinations of components reared their confusing heads in issues that were even more important: wilderness, recreation, land in its natural state and terrain integrity. And of course, one cannot separate humans from the environment, particularly when the majority are Natives who have a holistic concept of the environment; that is, a human is one of the animals rather than the master. The effect of industrial man and his social system has serious implications on northern people's perception of life patterns and of land itself.

The scientists and engineers did not recognize the complexities and differences of the people in a northern ecosystem and so each started from his own benchmark—his discipline. Their research was of the basic kind—base line research—and everyone concentrated on that without particular concern about how they were going to convert this base line data into impact assessments.

I think this is one of the most basic problems of the impact assessment process, and am convinced that what is needed, rather than academic research or an understanding of one component of the environment, is an understanding of the whole. If an industrial development is to change the environment, then we must know how to manage those changes. A complex system has many interactions between the biological, physical and human environments. To merely pass a regulation that limits one part of the system will not accomplish much, and in fact may do more harm than good. Clearly, management of the impacts with a social goal in sight is needed. Management tools such as regulation, persuasion, cooperation programs and incentives would be used to achieve that goal.

Base line information is ideal for understanding a component, and if you went far enough you could predict impact, but when your time and money had run out, you'd have collected great gobs of base line information—to what end? The proponents of the project draw the conclusion that the impact would be negligible and the detractors draw the conclusion that the impact would be unacceptable. The research has been for naught.

And now to our second decision, which was made by Donald MacDonald, then Minister of Energy, Mines and Resources, who said it would be better to have

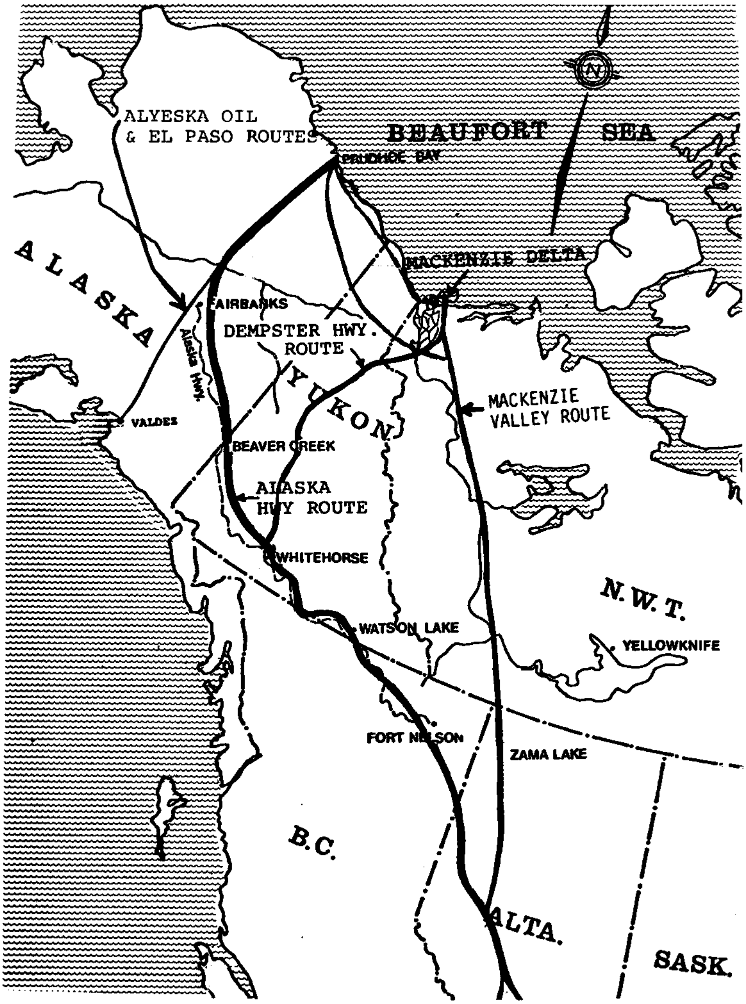

Figure 1. Proposed gas lines from the western Arctic.

only one applicant for the project, and so forced a shotgun marriage of the two applicants. Why this was done was never explained except with the very feeble excuse that Canada did not want to differentiate between two competing applications. It is perhaps interesting that Mr. MacDonald is now a director of McDonnell-Douglas Aircraft, and I wonder if his views on competition are the same.

The Government of Canada, in a surprise move, decided to subject the pipeline to a public inquiry. This was an unusual move for the Canadian government because it does not usually make its decisions in public. We speculate that perhaps the fact that there was a minority government in Ottawa at the time may have prompted this democratic way of going about things. But it is not for us to look a gift, or should I say democratic, horse in the mouth. And the government did many things right. It funded the hearings and citizens' groups so that they could have a reasonable amount of representation. It did not overwhelm the hearings with large numbers of bureaucrats. And it appointed a judge who was not a Liberal hack but an NDPer who had an appreciation of the Indian problems, to conduct the inquiry.

Mr. Justice Thomas Berger visited not only the communities on the Mackenzie River, but all the communities that might be affected. He went at a leisurely pace, at the Natives' time scale. He went to the communities, rather than bringing the communities to him. He let them speak, and if it was necessary to come back, he did. He insisted that his hearings be reported over the northern network in Loucheux, Slavey, Chipewyan, Dogrib and Inuit, and all in all, his very openness and accessibility let the northern people know what was going on and feel a sense of participation in a decision which would seriously affect them, their culture and way of life. This had to be a first.

Judge Berger listened to the people and heard such pleas for help as this one, from Les Carpenter of Sachs Harbour, a small community on an island in the Arctic Ocean:

> When representatives from oil companies come in for meetings, they bring us free movies. They talk to us about the things that they want and one of the problems when they talk is that they use all these great big words—I call them $80 words that the people don't understand. And when we say "no" to what they want they go ahead and do it anyway.

Judge Berger listened to this definition of land ownership, from Leroy Little Bear:

> Ownership does not rest in any one individual, but belongs to the tribe as a whole, as an entity. The land belongs not only to the people presently living, but it belongs to past generations, and the future generations that are yet to be born. Past and future generations are as much a part of the tribal entity as the living generation. Not only that, but the land belongs not only to human beings but also to other living things; they too have an interest.

And what of we more prosaic types: biologists, scientists, engineers, and wildlife experts? Yes, Berger listened to us too, but we have much to learn about how to put our scientific knowledge into a form that the decision makers can or will use. With our passion for technical accuracy about one small environmental concern, we failed to see the larger picture. Maybe we who work on impact assessments and argue for recognition of the importance of our pet component of the environment should try the holistic approach of the Natives, both Indian and Inuit, to "The Land."

In addition, we disdained the need to communicate to the public in general and the northern people in particular. That is not quite right. My group did publish a communication that received widespread coverage. It was a drawing of two birds on a small stunted northern tree. The tree was surrounded by bearded biologists with every kind of camera and recording apparatus made in Japan. One bird said to the other, "When you are up to your ass in biologists, it is hard to remember that we came to the Arctic to copulate."

We also put out technical reports. But no one read them.

Now let us look at the decisions made by the applicants. Despite Mr. MacDonald's desire for only one applicant, two finally showed up. The shotgun marriage didn't work. The big applicant, Canadian Arctic Gas, was composed of the international oil companies which spent a reported $200 million to prepare the application. The other one was Foothills Pipe Lines Ltd. which had spent a comparatively small amount of money and had done a small amount of research, but remained flexible.

Canadian Arctic Gas, the big applicant, decided early that the route it should take would be along the Arctic Coast. It did not consider an interior route, although one was available. It did not consider the Alaska Highway route, despite the fact that many people inside and outside the company argued loud and long that since there was already a right-of-way in both Canada and Alaska, the damage to the environment would be much less if the line was constructed along the Alaska Highway. But Canadian Arctic Gas never really considered this route, and with that blunder, the major oil companies, some of the largest in the world, blew $200 million, and lost the chance to get a rate of return on a $10 billion investment.

By January 1, 1976, half way through the Berger Hearings, Canadian Arctic Gas changed over 50 percent of its proposed route. One of the changes involved crossing the mouth of the Mackenzie Delta with the pipeline. Since the Mackenzie Delta is the only major delta in North America which feeds the Arctic Ocean with warm water and nutrients, the implications were serious. With the change in route, the company's engineers and scientists were faced with having expressed their opinions on an obsolete route.

In August 1976, Foothills Pipe Lines, having read the signs that approval of the Canadian Arctic Gas application was not automatic, started studying the feasibility of the Alaska Highway route. Berger's report came out, saying that Canada should not approve the coastal route under any circumstances, and recommending no pipeline should be built along the Mackenzie Valley for at least 10 years because of the social disruption to the Native peoples. Talk about "ecofreaks" was the order of the day in the corporate board rooms of the international oil companies.

When the National Energy Board, whose job it was to study the national issues and the economic feasibility and adequacy of the pipeline, brought out its report a month later accepting Berger's prohibition of the Coast Route and the 10 year delay for the Mackenzie Valley route, the board rooms echoed with consternation and anger. They said that the application could just not be turned down after $200 million had been spent. There was talk about the people freezing in the dark when there was not enough natural gas. And of course they pointed out that Canada could not exploit its Mackenzie Delta resources if the Alaska Highway route was used.

It is interesting, here, that the National Energy Board approved a route which no one had studied. They not only approved the Alaska Highway route but they approved a lateral line from the Mackenzie Delta along the Dempster Highway—some 730 miles (1170 km)—to hookup with the Alaska Highway pipeline at Whitehorse. This led to the engineering cynics saying, "The Mackenzie Valley route was studied and its problems discovered, so the NEB approved the Alaska Highway route because it hasn't been carefully studied and the Dempster Highway hadn't been studied at all." Cynics would draw the conclusion that if you want a route approved, don't study it.

The applicant, Foothills Pipe Lines, is still required to prepare an impact assessment of the Dempster Highway route by July 1, 1979. It will be interesting to see whether there is really a "no-go" alternative available to Canada or whether it can only design mitigative measures to reduce the impacts.

Unless the governments of Canada and both the Yukon and Northwest Territories can provide a pretty definite warranty that they can and will protect the Porcupine caribou herd, then I believe there should be no Dempster pipeline and there should be winter closure of the Dempster Highway. To you Americans who are worried about freezing in the dark, don't worry, the Alaska Highway does not go through the Porcupine caribou range!

But was the danger to the Porcupine caribou herd considered by Canada's decision makers? By August 2nd and 3rd, 1977, all of the reports of seven year's study were in and I journeyed to Ottawa to hear the special session of parliament—the great pipeline debate. The scientists and engineers had prepared a roomful of reports on environmental and social impacts, on the engineering feasibility, on economics, etc.—all designed to advise the Parliamentarians how to make the Canadian decision. I was most interested in seeing how our Members of Parliament would bring these reports together to make the decision. Basically, they did not.

They were caught off guard. They had formed their opinions—pro or con—on the Canadian Arctic Gas application and when that application was turned down by the National Energy Board, the politicians were caught with their decisions having been made for political reasons, and they really didn't know what to say.

It is understandable, therefore, that when parliament met to decide whether to build the pipeline, the Parliamentarians looked like little boys who had been out smoking behind the barn and had not done their homework. Most adopted the stance of giving "overviews." In the words of the government leader, Mr. Allan MacEachen, "Therefore, it will be no surprise to the honourable members that it is not my intention in this statement to make any announcement with respect to a decision but rather to indicate some of the issues which have to be considered and some of the problems which are involved in dealing with this important matter." Later on he said, "Today I would like to try to provide an overview of the long train of events leading up to the point of the decision, etc." It became pretty obvious that parliament would not be the vehicle to bring together all of the reports which had been prepared and I went home a saddened and a wiser man.

But herein, I think, lies the moral of my story. The scientists and engineers, in writing their reports, sometimes geared their efforts towards publication in a learned publication, with an audience of scientists with a similar training. The engineers were writing their reports on the economic adequacy of the structure they were designing. None of them, nor their employers, ever put the whole into a picture that the decision makers, who were the Parliamentarians, could or would attempt to understand. So the Parliamentarians took off from their own benchmarks—the political system—and made their own decisions. In this $10,000 million decision, which will affect not only the economy of Canada but of the United States with its huge energy deficit, there was no clearly understandable discussion of the most significant issues.

The discussion of slimy sculpins, ducks, geese, Native rights, energy policy, life patterns of the people along the route, balance of payments to Canada and effects on inflation all needed to be weighed along with the effect on the Porcupine caribou herd. The technical community is responsible for weighing the relative importance of these elements and communicating their findings to the politicians. And they did not do it.

However, there was great progress made in coming to this Canadian decision. The Berger Commission established a new standard in Canada of holding open hearings which are full and thorough and in which the people who are affected by a project can be heard in their own time frame, in their own language and in their own way. Mr. Justice Berger set the theme in his report:

> The North is a frontier, but it is a homeland too, the homeland of the Dene, Inuit and Metis, as it is also the home of the white people who live there. The decisions we have to make are not, therefore, simply about northern pipelines. They are decisions about the protection of the northern environment and the future of northern peoples.

The Government of Canada funded interest groups, including the Native organizations, which is a major step forward. It became very obvious at the hearings that the northern people were interested and wanted to participate in this national issue. At Fort McPherson, Phillip Blake said:"Mr. Berger, I guess what I am really trying to say is can you help us? And can we help you make sure that the will of the people is respected? After all, isn't this supposed to be what Canada once stood for? Can we as an Indian nation help Canada once again become a true Democracy?"

Not only the northerners, but all Canadians indicated their interest by turning the report into a best seller.

But some of us in the technical community did not come out so well. When you look at the role played by all of us, you find that we were looking down our own little tunnel and seeing either our own face at the end of it or those of our peers. The big questions in our complex society are: "How do we get the 'overall picture?' How do we expand our tunnel into the national or even international tunnel?"

Berger had terms of reference that limited his scope to the environmental and social implications of the Mackenzie Valley route; the National Energy Board looked at the adequacy and economics; the Lysyk Hearing looked at the socioeconomic aspects of the Alaska Highway route and the Hill Hearing looked at the environment of the Alaska Highway route. But no attempt was made to bring all of the environment (including the human environment) and the project issues together with those of the national economy or the national policies; nor such national economic issues as the cost to Canadian government, revenues to government, balance of payments, effect on inflation, effect on employment and effect on personal disposable income, nor such policy issues as effect on energy policy and effect on Native rights. Herein lies our greatest need. You who have learned the impact assessment process well, should now extend your knowledge as citizens to assist in the national decision making and to not only assist but to demand that the decisions in a democratic country be made in the open, in a democratic way and in a language that the people of the country can understand.

An interesting attempt at reconciling economics and environment was proposed by the Lysyk Commission. The National Energy Board concurred. We know that the people of southern Canada and the U. S. will receive the benefits of building the pipeline while the people along the route will be hurt by it. The Commission recommended that the project finance a $200 million Yukon Heritage Fund to pay the people for the indirect social impacts that the project will cause. As Lysyk said in his report,

> But what of the unquantifiable—although nonetheless real—costs that whole communities must bear in terms of social and economic dislocations and of unwelcome changes to their lifestyle? These social and economic costs will also be experienced in the Yukon, not in Ottawa or in Canada as a whole.

Unfortunately, the concept was thrown out in the Canada–U. S. Treaty negotiations. I hope it will not be forgotten, because what is good for General Bull Moose is NOT always good for the people.

In closing my talk of a democratic country stumbling to a decision, I would like to make a plea:

When all the data has been presented,
When all of the tables have been tabulated,
When all of the scientific proofs have been documented,
And all of the bitter tears of cynicism have been spent,
Please remember that the real success of your impact
assessments will be measured not by size of the volumes
but by how well they have convinced the decision makers to
protect the environment for future generations.

New Dimensions in Wildlife Management

Chairman:
GEORGE F. MATTFELD
Supervising Wildlife Biologist
New York State Department of Environmental Conservation
Wildlife Resources Center, Delmar
Cochairman:
DAVID NEAVE
Director of Wildlife
Alberta Fish and Wildlife Division
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Theory in Wildlife Conservation and Management

Thomas D. Nudds
Department of Zoology, University of Western Ontario, London

Introduction

Fretwell (1972) equated ecologists with "field" competence and those with "theoretical" competence to homozygous genotypes specializing on patches of habitat in a heterogeneous environment, e.g., perhaps a traditional wildlife school for those with field competence and an "ivory-tower" institution for those with theoretical competence. In Fretwell's model, "fitness," defined as the ability to make satisfying advances in the science of ecology, was greatest for the "heterozygote," a scientist with mixed training who was moderately competent in both field and theory; however, he pointed out that the mixed-strategy scientist would be justly criticized for incompetence by both "pure field" and "pure theoretical" ecologists.

Intermediate "patch-types" available for colonization by mixed-strategy scientists have been traditionally rare because there has been a substantial gap in the applied and pure approaches to ecological research (e.g., Bingham 1975). A major stumbling block to a union of Fretwell's genotypes is the opposing views about the analysis of "ecosystem" structure and function. In one view, the ecosystem is regarded as the sum of its parts and any understanding of organization and function above the level of the species can only come from a detailed knowledge of the physiology, behavior, genetics, and so forth of individual species; the other view holds that ecosystems are more than the sum of their parts and that the uniqueness of species contributes little or nothing to the uniqueness of the ecosystem (Smith 1975). Although both views have validity and are less in conflict than may first appear, applied factions have tended to favor the former approach, the generality of the latter approach rendering it not useful for applied purposes. The species approach is the heart of evolutionary ecology (Smith 1975:2), and studies on enough species will collectively, and given enough time, provide an evolutionary understanding of the form and function of the system. However, evidence of convergence of form and function in geographically-distinct communities (e.g., Cody and Diamond 1975) lends credibility to the ecosystem approach.

I propose that the ecosystem approach should receive more attention in conservation and management planning. This necessarily entails the use of general principles, and, as with all generalizations, there is a loss of information that accompanies the shift away from the specific. However, the gain in general insight from basic, theoretical research might pay dividends in management studies and practices (Orians 1973). Accelerating changes in the wildlife profession dictate that conservation and management research will become more compatible with the quest for "basic" knowledge (Reid 1968). For example, multi-value decision making in response to demands from a wider range of public attitudes about the use of resources (e.g., Eastmond and Kadlec 1977, George et al. 1974, Scheffer 1976) will mean that more emphasis will be placed on a "wholeness-of-nature," or ecosystem approach to management. Wagner (1977) pointed out that, too often in management decisions, species are treated in isolation, when in fact each is a part of an interrelated system. The results can be disastrous. Finally, the time element involved in, say, impact studies will not often allow the collection of data which would be considered sufficient by proponents of the species view of ecosystem analysis. Thus, research which sacrifices detail in favor of discovering broad, applicable principles can be useful, not *despite* its generality, but *because* of it. However, I suggest only that we are on the threshold of "managing" ecosystems and that an understanding of pattern and process at this level of biological organization is imperative. Three examples which draw on information from both the pure and applied literature illustrate my argument. The examples are admittedly biased and reflect my own interests in competition and species-packing theory to the exclusion of other significant work which has spearheaded in this direction (see Patterson 1979).

Interspecific Competition

What effects do introductions or removals of species have on the welfare of other species? The range-management literature, for example, is full of allegations of "competition" among wild ungulates, or between wild ungulates and cattle, based on, for example, the demonstration of simple overlap in habitat use and/or diets. Theoretical ecologists, however, will not accept these data as evidence of competition because the necessary condition for competition to occur, that is, resource limitation of population growth, is rarely, if ever, demonstrated. Simple resource overlap, in the absence of density-dependent population growth, can be interpreted as representing a lack of competition. But, when sufficient information is available to document density-dependent population growth, the arsenal of theoretical studies and empirical data on competition can be brought to bear on the problem.

For years there has been disagreement among waterfowl biologists as to whether coots *(Fulica americana)*, through their agonistic interactions with ducks, inhibit duck production by limiting nesting, feeding, or loafing sites. Lotka-Volterra-based competition theory (see Pianka 1976) predicts that, if coots compete with ducks, then inverse relationships should exist in pairwise comparisons of densities of coots and densities of individual species of ducks. Note that nothing specific is implied about the actual mechanism of competition, that is , whether it is for food, nest sites, or whatever.

The use of Lotka-Volterra theory as a basis for generating testable hypotheses is justified because first, there is considerable empirical support for the theory, despite its restrictive assumptions (see especially Istock 1977), and second, waterfowl populations show evidence of density-dependence during the breeding season. For example, Crissey's (1969) mallard data show that population size as a function of pothole abundance (= breeding habitat availability) can be described by the equation $y = 4.19\,x^{.2}$. M. L. Cody (personal communication) suggested that a function of this form is adequate evidence of density dependence. Space does not permit listing more evidence of density-dependence; it is available upon request.

Previous attempts (e.g., Munro 1939, Ryder 1959) to find inverse relationships between coot density and measures of duck breeding activity (e.g., brood size, nest success) failed because (1) they were restricted to short periods of the breeding season, (2) few data were collected in short-term studies, or (3) variation in pond abundance, to which coots and ducks alike respond positively, masked relative changes in coot and duck population sizes. My approach has been to use 26 years of waterfowl and coot census data (3 censuses yearly in May, June and July) and pond abundance data from the 5-mi² (12.8-ha) Redvers Waterfowl Study Area (40-mi [64.4-km] transect) in southeastern Saskatchewan (Stoudt 1971, 1973), and to statistically control variation in pond abundance by using partial correlation. Dzubin (1969) outlined biases inherent in the use of transect data, but because I infer nothing about absolute population densities, and instead employ indices of population size, these data are entirely adequate. Each correlation was done using data from the appropriate census period, since nesting varies temporally among anatids.

The results (Table 1) showed no pattern that was consistent with the hypothesis that coots suppress duck populations in the nesting period. Only 5 of 11 correlation coefficients were negative and none were significant. Similarly, no suppression of brood densities could be detected either (Nudds unpublished). Thus, the

Table 1. Eleventh-order partial correlation coefficients of duck species' densities with coot density at Redvers, Saskatchewan, holding pond abundance and all other species' densities constant. Each significance test is one-tailed; none of the relationships are significant at $p < 0.05$.

Species	Partial correlation with coot density		
	May	June	July
Mallard	−.13		
Gadwall		.28	
Pintail	.51		
Green-winged teal		.03	
Blue-winged teal		.12	
Wigeon		.38	
Shoveler		.67	
Redhead		−.41	
Canvasback	−.39		
Lesser scaup		−.06	
Ruddy duck			−.14

testing of historical waterfowl data against predictions from theoretical models proved useful in shedding light on an old, and often controversial, problem.

The Diversity of Species

An evolutionary consequence of interspecific competition is the diversification of the ways in which species utilize habitats, and, hence, structurally-diverse habitats promote species diversity. The analysis of factors that influence diversity has formed the basis of much work in theoretical ecology. Suppose that management for diversity is a valid objective (Pimlott 1969) and does not preclude management to protect rare or endangered species (Siderits and Radtke 1977; but see Webb 1977). Management for diversity dictates an ecosystem-, as opposed to species-management approach. Such management is useful in multi-use areas (e.g., Hooper and Crawford 1969, Reid 1968).

Vertical Habitat Complexity

Since MacArthur and MacArthur (1961) showed that bird species diversity (BSD) increased with the vertical component of habitat structural complexity, specifically foliage height diversity (FHD), many studies from various locations have demonstrated similar relationships (Table 2). When adjustments for scale are made, the slopes of the regressions do not differ (Willson 1974). This property enabled "theoretical" ecologists, interested in the explanation of latitudinal diversity gradients, to reject the idea that greater habitat complexity alone could account for higher diversity in the tropics. However, this constant-slope property may be useful as a predictive conservation tool. When a BSD-FHD relationship is well-documented for a region, such as eastern deciduous forests (MacArthur and

Table 2. Summary of empirical evidence of a relationship between bird species diversity (BSD) and habitat structural complexity (FHD).

Locality	Equation[a]	Source
Eastern temperate forests	$y = 0.46 + 2.01x$	MacArthur and MacArthur (1961: 596)
Eastern temperate forests and Chiricahua Mountains, S.E. Arizona	1.75	MacArthur (1964: 388)
Eastern temperate forests, Puerto Rico and Panama	(1.75)	MacArthur, Recher, and Cody (1966: 322)
Illinois	$y = 1.52 + 1.68x$	Karr (1968: 354)
Eastern temperate forests and Australia	(1.75)	Recher (1969: 77)
Illinois, Texas and Panama	no equation given	Karr and Roth (1971: 425)
Illinois	$y = 0.55 + 1.44x$	Willson (1974: 1019)
Peru	no equation given	Terborgh (1977: 1009)

[a]When no equation is given, the authors either stated the slope of the line (unbracketed numbers) or implied, by plotting points on similar figures, that the slopes of the lines were as reported by other authors (bracketed numbers). y is BSD, x is FHD.

MacArthur 1961), and coupled with a detailed knowledge of the vertical distribution of birds (e.g., Dickson and Noble 1978), reasonably accurate predictions of faunal changes in response to foliage profile manipulations may be possible. A regional "baseline" BSD-FHD relationship is necessary because in species-rich areas, birds subdivide horizontal foliage layers finely, i.e., behave as if they recognize more foliage layers, and in species-poor areas, behave as if they recognize fewer (MacArthur et al. 1966, Terborgh 1977). Also, in some habitats, FHD is not a good predictor of BSD and a knowledge of other structural habitat attributes is necessary to predict BSD (e.g., Tomoff 1974, Terborgh and Weske 1969).

Parks and urban developments represent types of habitat modifications where a knowledge of the BSD-FHD function may be useful in the planning stages to minimize disturbance effects. Linehan et al. (1967), Burr and Jones (1968), Emlen (1974), Hooper et al. (1973), Hooper et al. (1975), and Gavareski (1976) demonstrated the importance of adequate structural diversity and amount of vegetation to support a diversity of urban birds. For example, although she did not calculate FHD, Gavareski (1976) used the presence and condition of the major foliage strata as indicators of structural diversity and compared urban parks of varying size and vegetation complexity in Seattle, Washington, to a forest which served as a control. Since each stratum (canopy, understory, shrub, and ground cover) was present, the control was the structurally most diverse habitat and had the highest number of bird species. BSD declined with an increase in vegetation modification and decrease in park size (see also below and next section). From a knowledge of the habits of particular species, Gavareski could suggest which species were selectively removed and which were favored by modifications to different layers of vegetation. Emlen (1974) also concluded that habitat complexity, created by man-made structures, increased bird diversity in Tucson, Arizona.

Up to this point, the effects of habitat modifications on BSD have not allowed, except for educated "guesswork" by Gavareski (1976), more precise predictions of the selective effects on particular species of modifications to various portions of the foliage profile. The point-census technique (MacArthur et al. 1962), which utilizes known foliage-profile characteristics for individual species to predict bird censuses from habitat structure measurements, should prove useful in this regard. I am not aware of any other application of it, however. This could prove to be a fruitful area for investigation.

Horizontal Habitat Complexity

In homogeneous habitats, FHD can adequately predict BSD, but in heterogeneous environments, a simple relationship does not exist. The horizontal component of structural habitat diversity, or spatial complexity, can have an additional, independent influence on BSD (MacArthur 1964). Generally, fewer empirical studies by "theoretical" ecologists (e.g., Tomoff 1974, Wiens 1974, Roth 1976) have examined the relationship between within-habitat spatial heterogeneity and BSD. Importantly, these studies were conducted in vertically simple habitats such as desert and grasslands. Increased spatial complexity did not consistently increase BSD. On the other hand, between-habitat spatial complexity is a more widely recognized phenomenon, and it is this type of spatial complexity that Siderits and Radtke (1977) recognize will positively influence diversity.

The basis of the species-area relationship (Preston 1948), is that increasing area allows for the inclusion of more varied habitats and, hence, more varied species. The interrelation of area, spatial heterogeneity, and FHD make it difficult to disentangle their effects on BSD. Obviously, this general approach to predicting and conserving biological diversity, not only in birds, but in other taxa as well, is still in its infancy, but conservation and management research can help to add additional information needed to evaluate the approach as useful in applied circumstances. Here I can only reiterate MacArthur's (1964) plea for more data.

Island Biogeography and Nature Reserves

Terborgh and Weske (1969) studied the colonization of secondary habitats by Peruvian birds and found that FHD poorly predicted BSD. They attributed some of the variation in BSD to the proximity of some of their study plots to habitats which served as source areas for colonizing species. Distance was the complicating variable. Area is also a complicating variable when considering the effects of spatial heterogeneity on BSD (see above). Considerations of these two factors bear importantly on applied problems. Area, for example, in part determines the number of species on tracts of land from the sizes of city parks (Gavareski 1976) and woodlots (Burr and Jones 1968, Moore and Hooper 1975) to national parks (Terborgh 1974).

Because such tracts represent functional islands surrounded by "seas" of unsuitable habitat, it is not surprising that the mathematical formulations of equilib-

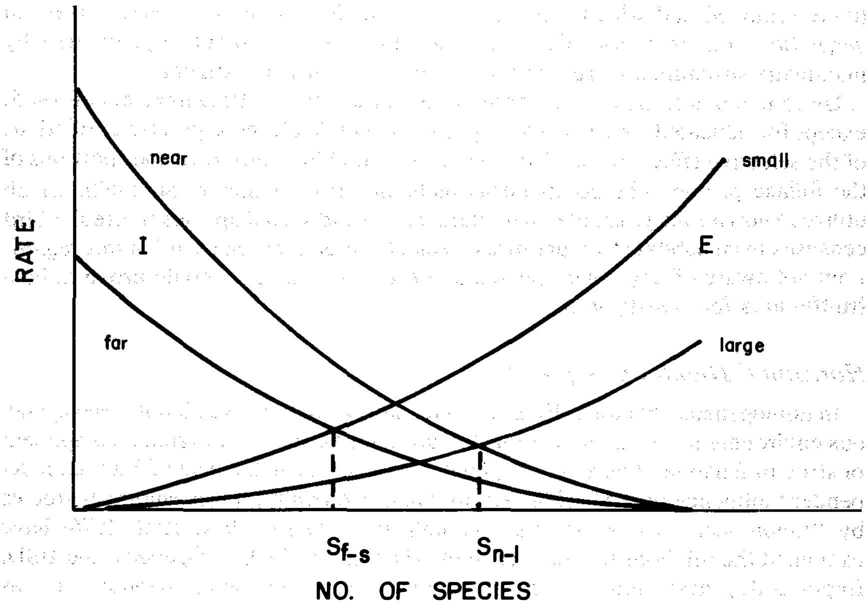

Figure 1. An equilibrium model of the number of species on islands of varying size and distance from a source of colonizing species. Increasing distance lowers the immigration (I) curve and increasing size lowers the extinction (E) curve. (After MacArthur and Wilson 1967.)

rium island biogeography theory (MacArthur and Wilson 1967) were quickly applied to problems of the size and shape of natural reserves. Distance and area, by affecting species immigration and extinction rates, determine the equilibrium number of species on islands (Figure 1). Thus, as experimental evidence (Simberloff and Wilson 1969, 1970) has confirmed, large islands near a source of colonizing species support more species than similar islands at some distance from the source of colonists. At equilibrium, as many species should become extinct on an island as immigrate to it. The theory served importantly to point out that previously unappreciated high extinction rates would be a consequence of a series of small, widely separated wildlife reserves (Kolata 1974).

However, work in this area has gone considerably past this point into considerations of non-equilibrium island biogeography. Since parks can be treated as islands, researchers are able to predict rates of extinction and, therefore, the number of species likely to survive in reserves of various sizes, the types of species most likely to survive, and reserve designs that will minimize extinctions.

For example, knowing (1) that certain neotropical land-bridge islands were connected to the mainland about 10,000 years ago, (2) the number of birds presently on each island, and (3) that immigration was negligible, Terborgh (1974) found that the extinction parameter, k, in the equation

$$dS/dt = kS^2$$

where S = the number of species and t = time, was a decreasing function of island area (Figure 2). Diamond (1972, 1973) and Brown (1971; working with forest mammals on mountaintops in a desert "sea") showed a similar decrease in extinction rates with increased area. Terborgh then estimated k for Barro Colorado Island, a former-hilltop-turned-island during the construction of the Panama Canal. The island's birds were censused 50 years ago, and it is protected as a

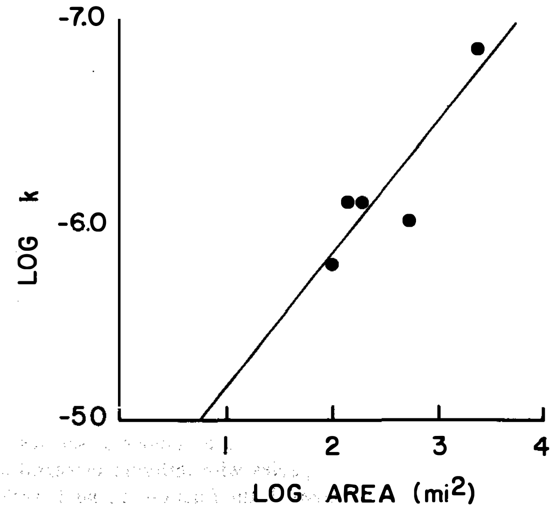

Figure 2. The extinction coefficient, k, as a function of island area. Extinction rates are reduced on larger islands. (After Terborgh 1974.)

wildlife reserve. Terborgh's estimate of 16–17 bird species lost from the reserve since its creation agrees closely with the actual number of 15.

So far, faunal survival has been discussed in probabilistic terms: what portion of an initial biota will a reserve save and how fast will the remainder go extinct? Diamond (1975a, Diamond and May 1976) has considered the survival probabilities of individual species, as these bear directly on conservation strategies. If

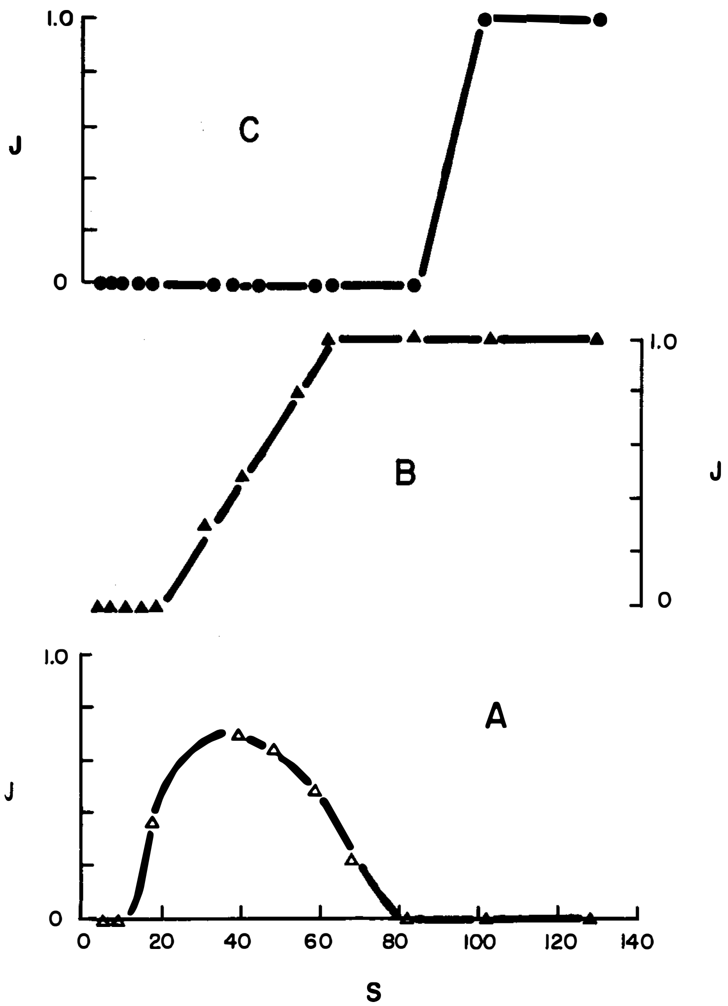

Figure 3. Three incidence functions which, because number of species (S) is correlated with area, represent the probability that species with different dispersal and competitive abilities will occur on islands of various sizes. J, the fraction of islands with given S-values on which the species occurs, goes to zero below some characteristic value for a particular species, meaning that there is no chance of long-term survival in areas below a certain size. (After Diamond 1975b.)

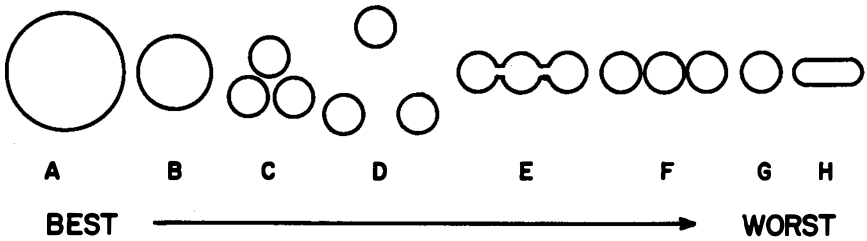

Figure 4. Nature reserve designs ranked according to their abilities to minimize extinction rates. (After Diamond 1975a.)

species have equal dispersal and survival probabilities, then large numbers of small reserves would be satisfactory. Each would lose species before reaching equilibrium, but with enough reserves, any given species would be likely to survive in at least one. On this basis, Simberloff and Abele (1976) questioned Terborgh's (1974) recommendation that faunal preservation could best be achieved by establishing single large reserves. As Diamond (1976) and Whitcomb et al. (1976) have adequately pointed out, however, the flaw in this approach is that species have very different area requirements which depend on different rates of immigration and extinction. Diamond's (1975b) approach to identifying species most likely to be present in reserves of various sizes has been to use "incidence functions" (Figure 3). Moore and Hooper (1975) similarly identified minimum area requirements for waterfowl on ponds of various sizes.

Finally, given that the number of species, extinction rates, and species-specific survival prospects vary with area, Diamond (1975a) proposed a schematic diagram depicting designs of nature reserves which would minimize species' extinctions (Figure 4). Whitcomb et al. (1976) agreed that this scheme would minimize local extinctions of birds of eastern forests.

Conclusion

I have briefly described three cases which suggest that broad principles derived from ecological theory are meaningful in applied contexts. I hope, however that my message has been two-pronged. First, technical research should be done in a theoretical framework. This framework allows for the smooth application of the scientific method which is hypothesis prediction and testing. Consider trying to build a picture-puzzle from a jumbled pile of pieces. When all of the flat-edged pieces are put together to form a general framework first, the remaining pieces of the picture fall into place easier. Note that this does not preclude rearranging pieces in the framework that are discovered to not fit properly upon closer investigation. Theory should function as the framework for the puzzle, or problem, in applied research. Second, "theoretical" ecologists would benefit by paying closer attention to the technical literature, for in it resides a good deal of empirical information with which to evaluate theory.

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Interests and Attitudes of Metropolitan New York Residents about Wildlife

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Introduction

Wildlife management in North America historically has been limited, in large part, to game management. Sportsmen have been enthusiastic conservationists, and they have been well organized, the result being that substantial sums—over $200 million annually in the U.S.—have been directed largely toward management programs that benefit game species.

The realization that programs of similar scale are needed for nongame species has attracted considerable attention (Gottschalk 1968, 1974, Greenwalt 1974, Doig 1974). Federal legislation for funding of nongame wildlife programs was introduced in Congress in 1976, 1977 and 1978. Missouri's "Design for Conservation" Program, funded by an earmarked one-eighth of one percent sales tax, has a strong orientation toward nongame uses (Noren 1978). Other states have also begun to direct at least limited resources toward nongame programs (Wildlife Management Institute 1975, Grieb and Graul 1975). Additionally, much of the notable work on wildlife in urban areas, including involvement of government agencies and private organizations, and research on the many facets of urban wildlife, were summarized in the symposia on "Wildlife in an Urbanizing Environment" (Noyes and Progulske 1974) and "Wildlife in Urban Canada" (Euler et al. 1975).

Yet, urban wildlife programs—meaning programs aimed at increasing species and numbers of wildlife in urban areas and educating urban residents about wildlife—are very much in their infancy. Nongame program efforts have thus far occurred largely outside of urban areas. If the wildlife management profession is to serve the needs of the majority of people where they live, it must progress not only beyond game management, but also beyond rural nongame programs and devote substantial resources to wildlife programming in urban centers.

New York's Urban Wildlife Program

New York's Department of Environmental Conservation (DEC) initiated one of the first state urban wildlife programs in 1973. The goals of the program are:

1. to increase the abundance, variety and visibility of desirable wildlife and their habitats in urban and suburban areas;

2. to increase urban and suburban residents' contacts with wildlife and encourage the understanding of ecological principles and concern for environmental conservation; and

A Contribution of Federal Aid to Wildlife Restoration Project W-146-R.

3. to preserve and enhance the long-term variety and biological productivity of urban and suburban areas as wildlife habitats.

Several DEC projects are currently underway: (1) an inventory of existing and potential wildlife habitat in urban and suburban areas (Matthews et al. 1977); (2) planning and developing the "urban wildlife parks" concept and an initial pilot park program in Albany; (3) the sale of shrub packets to residential landowners to attract and encourage songbirds in cities; (4) involvement in the protection of urban open space throughout the state; (5) the preparation of an educational packet for teachers; and (6) providing information to urban planners who wish to include wildlife considerations prior to actual developments. As is true of most other states, progressing beyond these initial efforts is dependent upon a larger funding base.

As the push for additional funding began, wildlife professionals in New York realized that the first question they, or any agency requesting additional funds, would likely be asked in justification of the request was, how will these funds be spent? What will the taxpayer receive for his tax dollars? It seemed that large portions of any nongame program should be devoted to urban areas where the majority of the population resides. But many questions remained. Are urbanites really interested in wildlife and, if so, what types and species? What kinds of programs would they participate in? Should programs be designed for children, adults, or both?

The U.S. Forest Service's nongame wildlife research program identified human preferences for wildlife species as an area in which major research is needed (Thomas and DeGraaf 1973). However, the only known previous study of interests of urban residents in wildlife was conducted in a relatively small area—Waterloo, Ontario (Dagg 1970).

To help ensure that New York's developing wildlife program would adequately serve the needs and interests of urban residents of the state, DEC contracted with the Department of Natural Resources at Cornell University to survey the interests, needs and attitudes of metropolitan residents in relation to wildlife, wildlife habitats, and wildlife-related recreation.

Study Goals and Methods

As is often the case in social research, there is a strong trade-off between alternative methodologies and their accompanying biases, variance, sample size and project cost. On the one hand, a study was needed which was as representative of New York's metropolitan publics as possible. However, specific quantitative values of precisely how many thousand people participated in bird watching, or kept feeders, were less important than answers to more general program planning questions. DEC staff wanted to determine whether sufficient urban interest existed to justify an urban wildlife program, what wildlife species were most preferred by metropolitan residents, etc. But on the other hand, it was felt that, in a state with such diverse metropolitan centers as New York City and Buffalo, interests and preferences might well differ, so sample sizes had to be sufficiently large to permit independent examination of the results from separate metropolitan areas. Furthermore, it would be desirable to be able to separate the attitudes and preferences of residents in suburban areas such as Westchester and Nassau Counties which border New York City, from those in metropolitan centers.

Based on these considerations, the survey was conducted by mail questionnaire. Samples were selected from telephone directories in each metropolitan center because more than 95 percent of the households in New York State have telephones (U.S. Bureau of the Census 1977). However, some bias was introduced due to unlisted numbers. Furthermore, the literature and our experience have shown that a respone rate of about 50 percent could be expected from a mail survey of the general public. These biases could be largely identified, however, by (1) comparing the demographic characteristics of the respondents to census data of the study areas, thereby identifying the orientation of survey bias, and (2) surveying a sample of mail survey nonrespondents to estimate the nonresponse bias. While this is a somewhat less accurate technique than the random-digit-dialing telephone survey conducted by market research firms, the mail questionnaire technique was judged to be sufficient for study purposes, and was less expensive (by approximately a factor of three) than a contracted telephone survey. As a result, for available funds, sample sizes could be increased to levels such that each metropolitan area could be examined independently.

After pretesting the questionnaire via a pilot survey of Albany residents (Dawson et al. 1978), the survey instrument was modified slightly and mailed to systematically selected samples of residents in New York City, Buffalo, Rochester, Syracuse, Utica-Rome and Binghamton. New York City residents were sent questionnaires in both Spanish and English, and follow-up reminders were used in all locales. Of 6,894 total deliverable questionnaires, 3,447 (50 percent) were returned.

This paper presents the major findings of the survey results and its implications for the development of a statewide urban wildlife program. An analysis of the survey results by residence areas has been reported elsewhere (Brown and Dawson 1978).

Results

Participation in Wildlife-Related Recreation

Seventy-three percent of study respondents participated one or more days in wildlife observation, feeding or photography in the 12-month period preceding the survey. The activity days were defined to represent conscious rather than casual efforts at participation (e.g. seek out and observe wildlife).

Sixty-four percent of the respondents observed wildlife, ranging from daily to only a few days annual observation. Of those respondents observing wildlife, 61 percent observed wildlife less than 60 days annually, with 27 percent indicating less than 10 days; while 24 percent participated on more than 180 days annually. Wildlife were observed most often around respondents' homes; 80 percent of all observation days were spent at these sites. Other sites were used less frequently, and percent of total observation days included: urban-suburban public parks (8 percent), rural private property (4 percent), urban-suburban private property (3 percent), rural public parks (3 percent), urban-suburban nature centers (1 percent), and rural nature centers (1 percent).

Wildlife were fed by one-half of the respondents; their total days of feeding were distributed over the entire range of one through 365 days. Of those repondents feeding wildlife, 64 percent fed wildlife on less than 60 days annually, with 34 percent indicating less than 10 days; while 20 percent fed wildlife over 180 days annually. Wildlife were most often fed around respondents' homes; these areas accounted for 86 percent of all these activity days. The other feeding sites used less frequently were: urban-suburban public parks (5 percent of the activity days), rural private property (4 percent), urban-suburban private property (3 percent), and rural public parks (1 percent).

Wildlife were photographed on one or more days by 18 percent of the respondents. Of those respondents photographing wildlife, 89 percent photographed on less than 60 days annually, with 58 percent on fewer than 10 days. The sites most often used for wildlife photography, by proportion of days spent, were: around home (32 percent), urban-suburban public parks (21 percent), rural private property (18 percent), rural public parks (15 percent), urban-suburban private property (6 percent), urban-suburban nature centers (5 percent), and rural nature centers (3 percent).

The proportion of respondents participating in consumptive wildlife-related activities was less than those participating in nonconsumptive activities (33 and 73 percent, respectively). Consumptive wildlife activities and proportion of respondents participating were: saltwater fishing (20 percent), freshwater fishing (19 percent), hunting (8 percent), and trapping (1 percent). The majority of respondents participated less than 20 days per year in these activities.

The wildlife habitat improvements that were maintained by respondents around their homes and the proportion of respondents involved were: bird feeders (34 percent), water structures for wildlife (16 percent), birdhouses (11 percent), and plants for wildlife (10 percent). Additionally, the respondent's family held membership in wildlife-related organizations and conservation or environmental education programs only infrequently (12 and 10 percent, respectively).

Interest in Wildlife

Sightings of birds, once or several times a day, were common for most respondents (62 percent) during their everyday activities. Mammals were sighted once or several times a week by most respondents (76 percent) during their everyday activities. Other wildlife, such as reptiles and amphibians, were reported as seldom or never seen by 92 percent of the respondents.

Although birds, mammals and other wildlife were sighted with different frequencies during everyday activities, the majority of respondents considered the observation of wildlife groups to be at least moderately important components of their outdoor recreation experiences. The observation of birds was considered to be at least moderatley important to 78 percent of the respondents, mammal observation to 74 percent, and observation of other wildlife to 63 percent of the respondents.

Respondents rated a list of 20 wildlife species groups according to the area nearest their home in which they would like to see each group (Table 1). The wildlife preferred around the home by the majority of respondents were butterflies, robins, cardinals, sparrows, blue jays, squirrels and hummingbirds. A second group of wildlife was generally preferred away from the immediate environment of the home—in nearby parks or in the country: woodpeckers, blackbirds-starlings, chipmunks, ducks-geese, frogs-toads, rabbits, pheasants and turtles. The wildlife least desired in the proximity of the home or neighborhood

Table 1. Respondents' preferences for the nearest area to their home in which they would like to see 20 wildlife species groups.

Wildlife group	Preference (%)				Mean distance rank of categories (0–3)
	Around home (3)	Nearby parks (2)	In the country (1)	Not at all (0)	
Butterflies	80.6	12.4	5.9	1.1	2.724
Robins	78.1	14.4	6.4	1.1	2.695
Cardinals	70.0	18.7	9.1	2.2	2.566
Sparrows	70.1	16.2	10.6	3.1	2.533
Blue Jays	65.5	19.9	12.1	2.5	2.486
Squirrels	53.0	29.5	13.7	3.8	2.313
Hummingbirds	54.9	24.0	15.1	6.0	2.276
Woodpeckers	37.2	31.3	26.2	5.3	2.004
Blackbirds-starlings	38.4	25.2	21.9	14.5	1.874
Chipmunks	26.7	36.1	31.1	6.1	1.836
Ducks-geese	13.6	57.4	26.0	3.0	1.816
Frogs-toads	24.1	38.5	28.8	8.6	1.781
Rabbits	19.4	33.4	42.5	4.7	1.673
Pheasants	13.7	39.3	42.5	4.5	1.622
Turtles	13.8	43.0	32.6	10.6	1.599
Pigeons	24.8	26.0	12.1	37.1	1.384
Raccoons	8.5	27.2	55.3	9.0	1.353
Foxes	4.1	20.7	59.5	15.7	1.133
Skunks	4.9	17.1	52.3	25.7	1.014
Snakes	7.8	21.8	33.4	37.0	1.004

included pigeons, raccoons, foxes, skunks and snakes. Respondents either preferred to see these wildlife in the country, or they had no interest in seeing them at all. Forty-four percent of the respondents claimed that there were not enough wildlife in their neighborhood to give them sufficient observation opportunities.

Wildlife-Related Problems

About 20 percent of the respondents reported a wildlife-related problem; they were able to solve these problems 39 percent of the time. Wildlife problems were characterized most often as general nuisance (71 percent), followed by damage to gardens (17 percent), damage to buildings (7 percent), competition with other wildlife (3 percent), and damage to landscape vegetation (2 percent). For respondents with wildlife related problems, the wildlife species most frequently cited were: squirrels-chipmunks (31 percent), pigeons (23 percent), raccoons (14 percent), blackbirds-starlings (7 percent), rabbits (6 percent), and skunks (5 percent).

Nuisance problems apparently were not at a level which stongly discouraged interest in backyard or neighborhood wildlife. Although 20 percent of the respondents reported wildlife-related problems, 38 percent of those with problems indicated that not enough wildlife were in their neighborhood for sufficient observation opportunities. Respondents with wildlife-related problems were also as interested in learning how to encourage wildlife to live in their backyard or neighborhood as those respondents who did not report problems.

Interest in Wildlife-Related Programs

The vast majority of respondents (96 percent) indicated that it was important for children to have the opportunity to take part in nature programs beyond those offered in school or at home. Of those respondents with school-aged children, 50 percent expressed interest in having their children participate in a neighborhood wildlife identification program, and 43 percent expressed interest in having their children participate in a program to study the life cycles and habits of neighborhood wildlife. Adult interest in participating in a neighborhood wildlife identification program was indicated by 36 percent of the respondents, while a program to study the life cycles and habits of neighborhood wildlife was of interest to 30 percent.

Seventy-three percent of the respondents expressed interest in a program to learn how to encourage wildlife to live in their backyard or neighborhood area. Interest in such an enhancement program was only slightly higher for respondents living in one or two family dwellings than for those living in multi-family dwellings (76 vs. 69 percent, respectively).

Due to the limited amount of open space in city areas, the use of cemeteries as wildlife observation sites was investigated and found to be acceptable to 65 percent of the respondents interested in wildlife observation. However, 27 percent indicated they would use cemeteries only if other areas were not available.

Respondents' Characteristics

Several demographic characteristics of survey respondents were compared with U.S. Bureau of the Census data for each of the residence areas sampled. When compared to adult census data, adult respondents could be summarized as having similar median ages, several more years of education, a substantially higher median family income, and were more frequently male (Brown and Dawson 1978).

The sample of nonrespondents to the mail questionnaire, who were interviewed by telephone, participated less in nonconsumptive wildlife-related activities and were considerably less interested in wildlife and wildlife-related programs than were mail questionnaire respondents (Brown and Dawson 1978).

Discussion

Respondents reported a high level of interest in wildlife and an awareness of the presence of wildlife in their urban and suburban surroundings. Although respondents experienced some nuisance and damage problems from wildlife, it was not at a level which discouraged interest in backyard or neighborhood wildlife. This was often related to the respondents' interest in encouraging the more preferred wildlife species to live near their homes, whereas most of their problems were due to wildlife which they preferred to have away from the immediate area of their residence. Management plans for urban areas need to consider the distance preferences and potential damage problems for each wildlife species to minimize the conflicts between wildlife and human use of an area. This will help to increase human enjoyment of these wildlife.

The intensive use of residential areas for wildlife-related activities and wildlife habitat improvements, and the high level of interest in encouraging backyard or neighborhood wildlife, make residential areas and backyards important areas for potential wildlife programs. This has also been indicated by the public acceptance of the backyard wildlife habitat improvement program promoted by the National Wildlife Federation (Thomas et al. 1973, Davis 1974). Other such programs promoted by both government agencies and private organizations would probably also be well received.

A carefully conducted program to promote the use of cemeteries as sites to observe wildlife in urban and suburban areas, as suggested by Thomas and Dixon (1973), seems feasible since this concept was acceptable to the majority of people interested in wildlife observation. While previous social norms would have likely found the use of cemeteries for recreation to be unacceptable, their use for quiet forms of recreation has increased in recent years. The use of cemeteries for wildlife observation could be tested as a pilot study in an area of limited open space to determine its acceptability.

Although only a small percentage reported that they had participated in conservation or environmental education programs in the year before the survey, respondents' interest in neighborhood education programs for adults and children establishes a large number of potential participants in programs to learn about wildlife identification and wildlife cycles and habits. The difference between the respondents' past rate of program participation and their higher level of interest in potential programs may be attributed to the possible location of future programs in their neighborhood, where respondents are already very interested in wildlife.

Programs that provide wildlife-related experiences close to home are appropriate as well to those members of the urban community who may lack the mobility needed to participate in recreational activities at more distant locations. The young, the elderly, the poor and disadvantaged, and households with very young children are often confined to their immediate neighborhood. These citizens can best be served by programs that encourage local area involvement.

The development of urban wildlife parks in densely-populated areas may be responsive to the needs of the survey respondents as well as to the nonmobile segment of the metropolitan area. The urban wildlife park could provide more local opportunities for wildlife viewing, environmental education and enjoyment of the outdoors. New York's DEC has begun to develop an urban wildlife park in the city of Albany to test the feasibility of such a project (Miller and Matthews 1978).

When generalizing these study results to the New York State metropolitan population, it should be remembered that nonrespondents represent 50 percent of the original deliverable sample. Results from the telephone follow-up of nonrespondents indicated that they were somewhat less likely than respondents to have participated in nonconsumptive wildlife activities, and are far less interested in wildlife programs. However, even if nonrespondents are assumed to have no interest in wildlife or wildlife programs, data from respondents indicate that more than a million households in New York State metropolitan areas would be interested in a program to learn how to attract wildlife to backyard or neighborhood areas and over one-half million households would be interested in programs to learn about wildlife identification and natural history.

In general, these study results support the National Urban Recreation Study (USDI 1978) recommendations that more environmental education programs should be initiated or expanded in urban areas. Education programs, including publications, could offer information on city field trips, on neighborhood wildlife and on the use of wildlife to demonstrate ecological principles to urban residents. Such programs might be developed and implemented by federal, state and local government agencies, or by private organizations which carry out recreation and conservation education programs. Formal and informal education programs could be offered by wildlife agencies, park and recreation agencies, and public school systems.

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Beliefs of Birders, Hunters, and Wildlife Professionals about Wildlife Management

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Introduction

One of the most pressing needs facing the wildlife management profession is to broaden its financial and political base beyond its traditional constituency of sportsmen. Though this is particularly apparent today in light of the fiscal strains and political assaults many wildlife agencies are experiencing, the need has long been recognized. Half a century ago, Aldo Leopold (1930) observed that the wildlife management profession would be most effective only if it drew support from a diverse constituency such as "sportsmen and other conservationists."

There are at least two ways to widen support for wildlife management agencies. The first would involve tapping the resources of the general public, as is done, for example, in California with general tax revenues, in Colorado with an income tax checkoff, and in Missouri with a one-eighth of one percent sales tax. These programs are successful to the extent that citizens or governmental representatives of the citizenry endorse wildlife conservation.

A second approach to increasing support for agencies would involve nonconsumptive wildlife users, like bird watchers, hikers, campers, nature photographers, and natural history enthusiasts. If wildlife agencies could ally nonconsumptive users and sportsmen, the financial and political base supporting wildlife management would be strengthened.

One coalition of nonconsumptive and consumptive enthusiasts considered as early as 1931 (Phillips) is that linking bird watchers with hunters and wildlife professionals. Recent estimates place the number of committed birders between 6 and 10 million (More 1979). These people represent a significant human resource largely untapped by wildlife agencies.

The question arises, however, do the wildlife-related beliefs of birders conflict so severely with the beliefs of hunters that a uniting of the groups in support of wildlife is improbable? Moreover, how receptive are wildlife professionals to incorporating new people, ideas, and emphases of a nonhunting nature into wildlife management? This paper summarizes the results of a survey (Witter 1978) designed to explore the potential for cooperation among these groups.

Methodology

Two hundred subjects were randomly selected from each of three national organizations: American Birding Association, Inc. (birders); Ducks Unlimited, Inc. (hunters); and The Wildlife Society (wildlife professionals). Each subject was sent a self-administered, mail-back questionnaire, and if needed, a reminder post-card and two follow-up mailings. Of the questionnaires deliverable, 180 were returned by birders (91 percent), 111 by hunters (58 percent), and 168 by wildlife professionals (93 percent). No follow-up study of nonrespondents was undertaken, so no evaluation of possible nonresponse bias can be offered.

Results

Socioeconomic Characteristics

The participants were highly educated, with wildlife professionals having an average of 18 years of education, birders, 17, and hunters, 15. As would be anticipated in light of years of education, many respondents' annual household incomes were substantial. Fourteen percent of the wildlife professionals had incomes of $30,000 or more, 37 percent of the birders earned $30,000 or more annually, and fully 51 percent of the hunters had earnings in this category. On the average, the wildlife professionals were younger than the other participants, with a mean age of 34. Hunters had an average age of 42, and birders, 49. Ninety-eight percent of the hunters were male, as were 92 percent of the wildlife professionals and 72 percent of the birders.

Based on this brief review of socioeconomic characteristics, the bird watchers in this study appear much like the committed birders described in two previous investigations of nonhunting wildlife enthusiasts (Kellert 1977, Shaw et al. 1978). The hunters, however, had more education and higher incomes than general hunter populations described elsewhere (Hendee and Potter 1976). Comparable data for other populations of wildlife professionals are not available.

Selected Wildlife Interests

For all three groups, wildlife appreciation is more than just one of many outdoor interests; it is the focal point of their recreation. Virtually all (97 percent) of the bird watchers listed birding among the three outdoor activities they most enjoyed, while almost all (93 percent) of the hunters indicated hunting to be among their three most enjoyed. Of the wildlife professionals, 67 percent listed hunting among their most enjoyed outdoor activities, and 39 percent, bird or wildlife watching.

A related question asked the subjects to indicate wildlife activities in which they considered themselves to be active participants. Eight percent of the birders were hunters, while 20 percent of the hunters classified themselves as bird watchers. Seventy-eight percent of the wildlife professionals were hunters, and 69 percent, bird watchers.

Birders tend to be actively involved in private conservation organizations. Almost all (91 percent) belonged or contributed to three or more conservation groups of a nonconsumptive bent (for example, Nature Conservancy, World Wildlife Fund, local or national Audubon Society, Sierra Club), with 80 percent supporting four or more such groups, and strikingly, over half (54 percent), five or more. By comparison, 6 percent of the hunters and 22 percent of the wildlife professionals belonged or contributed to three or more conservation groups of a nonconsumptive orientation.

Beliefs About Wildlife Management

Importance of Wildlife. Birders, hunters and wildlife professionals generally agree on the ways wild animals are valuable. Each subject was presented a list of 27 ways wildlife might be valued, and was asked to rate them on an 11-point scale, where 0 was "not valuable at all" and 10 was "extremely valuable." On the average, all three groups placed comparatively low values on the consumptive uses of wildlife (e.g., means for "wildlife as meat sources," "trophy sources," "fur and leather sources," ranged from 0.1 to 5 point each). The predictable exceptions in the consumptive category were the relatively high values attached to "wildlife as subjects to be hunted for sport" by hunters ($\bar{X}$ = 7.8) and wildlife professionals ($\bar{X}$ = 6.8).

In Table 1 are the three highest-ranking values for the groups. Birders and wildlife professionals assigned the most value to the same three items, with "wildlife as factors in nature's balance" placing first. Hunters also assigned this the highest value, but their remaining two items were different. Across groups, however, comparison of these three items indicates considerable agreement on the importance of wild animals in the man/nature relationship.

Management of Game and Nongame. Hunting has a role in wildlife management, in the opinion of these groups. A number of items in the survey dealt with hunting and the prevailing pattern of game and nongame management (see Table 2). The groups thought that government would not help wildlife by banning hunting, that hunting is essential to prevent overpopulation of some types of wildlife, and that hunting should continue as a wildlife management tool in the future.

Though bird watchers as a group approve of hunting, they are not satisfied with all aspects of wildlife management. Birders perceived an imbalance in game versus nongame management which is weighted toward the former. They felt that nonhunters should have a greater voice in wildlife management, to the point of equal say with sportsmen and representation on state game commissions. Birders thought the usual device for acquiring management funds, the state license or permit, was not a good way to generate nongame management monies, and that nonconsumptive enthusiasts should be given some other means of supporting agencies.

Bird watchers saw room for improvement in the present system, but they acknowledged the past efforts of wildlife agencies. They agreed that wildlife management as practiced today benefits not only hunters and fishermen but other

Table 1. Three highest-ranking reasons wildlife were valued.

Rank	Birders and wildlife professionals	Hunters
1	Factors in nature's balance	Factors in nature's balance
2	Subjects for nature study	Subjects to be hunted for sport
3	Subjects to be pursued and sighted for enjoyment	Help maintain the human bond with nature

Table 2. Percent agreement with statements about game and nongame management.

Abbreviated statement	Birders (N = 180)	Hunters (N = 111)	Wildlife Professionals (N = 168)
U.S. Govt. would help wildlife by banning hunting	8	0	1
Hunting is essential to prevent wildlife overpopulation	73	96	92
Hunting should continue as a management tool	75	97	97
Good balance exists in game/nongame management	8	38	17
Nongame welfare comes through game management	58	92	77
Nonhunters' say in agencies should at least equal sportsmen's	90	23	40
Nonhunters on game commissions would yield better balanced resource decisions	92	15	60
Nongame funds should come from license purchases	15	23	9
Agencies should give nonconsumptive users a way to contribute other than license purchases	88	94	96
Today's system of wildlife management benefits only sportsmen	11	2	2

wildlife users as well, and that the well-being of a large majority of nongame animals is achieved through game management.

Hunters were more supportive than birders of the prevailing pattern of wildlife management. They thought that a system emphasizing game production is justifiable in light of their support of agencies. There was, however, some uncertainty on their part as to whether the interests of wildlife users other than sportsmen are given fair representation in agencies. For example, 30 percent disagreed and 32 percent were unsure that a good balance now exists in game versus nongame management.

Almost all hunters agreed that agencies should give nonhunting wildlife users some means of contributing to nongame management other than license purchases. However, hunters' support for integrating nonhunters stopped short of equal power sharing; only one-fourth agreed that nonhunting wildlife users should have a say in agencies at least equal to that of sportsmen, and a smaller percentage thought that the presence of nonhunters on state game commissions would give better balance to commission decisions.

Not surprisingly, wildlife professionals favored increased recognition of nonhunters and nongame interests, though not to the degree preferred by birders. Generally, professionals felt the balance in wildlife management favors game, thought that nongame management should not be based on license receipts, favored giving nonconsumptive users some means of supporting agencies other than license purchases, and agreed that nonhunters on state game commissions would give better balance to commission decisions.

Cooperation Between Hunters and Nonhunters. Nearly all subjects felt that nonhunters and hunters can work together in at least a few ways for wildlife, and large percentages in the groups felt cooperation can take place in many ways. To pursue this idea further, each subject was asked to evaluate "hunters as a wildlife user group" and "bird watchers as a wildlife user group" using a 7-point semantic differential scale composed of seven sets of bipolar adjectives (e.g., outdated/up-to-date, spoilers/conservationists, unsporting/sporting). Birders were neutral in their appraisal of hunters, being neither strongly pro-hunter nor anti-hunter. Both hunters and wildlife professionals saw hunters (as wildlife users) in a positive light.

Of interest in the subjects' appraisal of "bird watchers as a wildlife user group" is not so much that birders saw bird watchers most positively, but that hunters described bird watchers (as wildlife users) slightly more favorably than they described hunters! There is a ready interpretation of this result. First, and encouragingly, these hunters had no quarrel with birders. Second, though these hunters saw the hunting fraternity in a positive way, they did not view the group through rose-colored glasses, and were candid in their appraisal. Wildlife professionals also saw "bird watchers as a wildlife user group" in a slightly more positive light than hunters (as wildlife users).

Funding Nongame Management. All three groups thought that the major part of nongame management funds should not continue to come from fees related to fishing and hunting. Well this is, for under the current system, the financial support of agencies by bird watchers is slight. Small percentages of birders bought federal duck stamps (6 percent), state hunting licenses (2 percent), or state fishing licenses (3 percent) for nonconsumptive purposes. However, their reluctance to support public programs should not be interpreted as an unwillingness to pay their own way in wildlife management. Any notion that these people do not "put their money where their hearts are" is quickly dispelled by recalling that 91 percent of the birders belonged or contributed to three or more conservation groups of a nonconsumptive leaning, and 54 percent, to five or more. This group provides substantial financial support for wildlife conservation, but not the programs of the public sector. Understandably, birders support private conservation organizations offering tangible products and services appealing to nonconsumptive wildlife interests. Birders' hesitance to purchase agency stamps and licenses is best interpreted as a sign that these wildlife users perceive few or no benefits coming to them from such purchases.

Participants were presented a list of 19 possible mechanisms for funding nongame management. When asked to select the one way they most favored, pluralities in all three groups selected methods which would involve the general public. Birders (23 percent) chose "use of general tax revenues," as did wildlife professionals (17 percent). Hunters (14 percent) selected "one dollar checkoff on federal or state income tax." When asked to select the way they favored second-most, pluralities of birders (14 percent), hunters (15 percent), and wildlife professionals (16 percent) chose "one dollar checkoff"—again, a method allowing the public to assume responsibility.

Two funding methods roundly rejected by all three groups were "increasing general property tax" and "increasing state sales tax slightly." Interestingly, the sales tax approach was approved by the general citizenry in Missouri, and is the financial base for conservation of fish, wildlife, and forests in that state.

Discussion

The results of this study indicate that the wildlife-related beliefs of birders, hunters and wildlife professionals are bases for cooperation in wildlife conservation much more so than grounds for confrontation. General agreement exists among the groups on (1) the values of wildlife, (2) the role of sport hunting in wildlife management, and (3) the desirability of tapping the financial resources of the general public to fund increased nongame management. Moreover, wildlife professionals appear to be receptive to people, ideas, and emphases of a nonhunting nature, and are suited to drawing nonconsumptive wildlife users into a conservation coalition with sportsmen.

With agreement existing among the groups on key points, why have wildlife agencies not been more successful in capturing the attention and support of birders? Several explanations can be offered. First, birders generally are not opposed to legal sport hunting and are not anti-hunter or anti-agency. Thus, one apparent reason birders have not sought to directly influence the prevailing pattern of wildlife management is that they are not opposed to the pattern, though they would welcome heightened attention toward nongame management. The thought that birders and nonconsumptive enthusiasts like them do not threaten the existence of the wildlife management establishment should reassure those sportsmen and those wildlife professionals who have grown wary of all nonhunters because of the anti-hunting controversy.

A second and more obvious reason for birders not supporting agencies is that bird watchers do not perceive them as active representatives of nonconsumptive wildlife interests. In this study, birders willingly acknowledged the past conservation efforts of agencies. However, they gave strong indication that as long as license purchases remain the primary means of supporting public programs, and as long as agencies appear to emphasize game management rather than management of all types of wildlife, their financial backing of government efforts will remain slight.

Another possible reason for their lack of support is their already active role in private conservation organizations. Though birders do not purchase licenses and federal stamps in large numbers, they still have an indirect but effective influence on public programs through the lobbying efforts of the private conservation groups to which they belong. Birders are thus able to remain nonaligned with agencies, while having their interests represented in agency decisions by private groups acting as go-betweens.

The lack of past cooperation between consumptive and nonconsumptive wildlife enthusiasts can also be addressed from the standpoint of hunters and wildlife professionals. For over half a century, these groups have enjoyed a mutually beneficial relationship. In exchange for harvest privileges and a game management emphasis, sportsmen have given wildlife agencies financial support. A hesitance to change this conservation partnership by including nonconsumptive users would be understandable.

Ironically, it is in this period when the hunting tradition faces its greatest challenge that drawing nonhunters into a conservation coalition with sportsmen could provide the political and financial reinforcement needed by wildlife agencies. After all, birders and nonconsumptive enthusiasts like them do not seek changes in wildlife programs and policies so much as the addition or expansion of nongame programs which appeal to their wildlife interests. They would welcome nongame habitat research, protection of threatened and endangered species, management of urban wildlife, and special programs such as birding tours and interpretive presentations.

Incorporating more nonhunting considerations into the programs of wildlife management agencies will undoubtedly require some compromises. Hunters may be expected to share representation on state wildlife commissions with nonhunters. There may be certain unique wildlife observation sites at which hunting is eliminated. However, the effects of such concessions on the interests of sportsmen may be quite minimal and even beneficial in the long run. Habitat management or preservation benefits all types of wildlife and wildlife enthusiasts.

Most of the programs nonconsumptive wildlife users desire will require funding to get off the ground. Acquisition of this money represents a serious problem for wildlife agencies, but one which certainly is not insurmountable, and one which nonconsumptive enthusiasts can help remedy. In 1976, for example, the Missouri Department of Conservation presented the citizenry a master plan for conservation of that state's fish, wildlife, and forests. This "Design for Conservation" called for departmental acquisition of roughly 300,000 acres (124,500 ha) for conservation purposes, and expansion of programs, including nongame operations. The financial base upon which this plan was to be grounded was a sales tax. This tax went before voters as a proposed constitutional amendment after more than 100,000 signatures were collected on petitions calling for consideration of the issue. In describing the collection of signatures, an Assistant Director of the Conservation Department commented, "Hunting and fishing clubs did well getting signatures, but the best petition carriers often were college students, birders and hikers" (Brohn 1977: 66). The sales tax issue passed and went into effect on July 1, 1977. It yielded more than $24 million the first year.

In this example, the attention of nonconsumptive wildlife users was captured by a state agency seeking to acquire wildlife habitat and expand nongame programs. As a result, they became a powerful constituency working to advance state agency efforts.

Encouragingly, this study indicated that birders, hunters, and wildlife professionals are moving toward the same end, wildlife conservation. But though they share a common goal, their paths are separate, with little being shared among them in the way of financial and political resources. Unitl nonconsumptive wildlife enthusiasts perceive that wildlife agencies are full time representatives of their interests, or until funding mechanisms are developed which make their participation in public programs mandatory, their resources will flow mainly to wildlife conservation programs in the private sector, and remain largely untapped by wildlife management agencies.

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Improving Ethical Behavior in Hunters

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In recent years an increasing concern for hunter ethics has pervaded the professional journals, the popular hunting and fishing magazines and even the major television networks. The interest in hunting behavior is not a new one. Over 30 years ago, King (1948) stated, "Biologists once dreamed of solving wildlife problems while the galleries cheered; wiser now, they see the need for human engineering as well as better research." Hendee and Potter (1971) renewed this plea when they commented on the scarcity of highly scientific research on human behavior aspects of wildlife management. They concluded that vigorous social-wildlife research is scarce despite extensive magazine and conference comments on the human behavior aspects of wildlife management. Over the past few years, many investigators (Shaw 1975, Kellert 1976, Langenau and Mellon-Coyle 1977, Gilbert 1977, Rohlfing 1978) have responded to this stated need for research on human subjects. These investigations have characteristically focussed on the attitudes, interests, and other characteristics of hunters as measured by mailed questionnaires or interviews. Few studies have been attempted which have included direct as well as inferred analysis of behavior. One of these, Pursley's research on New Mexico poachers (Crenshaw 1977), is particularly significant because of the data gathered on the extent of poaching behaviors and the stimulation it provided in the development of new problem-solving programs.

This paper will summarize the results of a study of the ethical behaviors and attitudes of a group of Wisconsin waterfowl hunters based on field observations, field interviews, and in-depth home interviews with the same hunters. From these results, the investigators will not only report the personality traits and hunting conditions associated with ethical and unethical behaviors but also offer a rationale for those forms of behavior management that could successfully change hunter ethics through the improvement of (1) regulations and enforcements, (2) the physical conditions associated with hunting, and (3) educational programming.

Methods

The waterfowl hunter study being reported is the initial investigation of the Wisconsin Hunter Performance Study, a project that will also evaluate the hunting behaviors of big game and small game hunters and utilize these findings in hunter education programs in Wisconsin. Waterfowl hunting is an important part of the total hunting opportunity found in Wisconsin. One-fifth of the estimated 720,000 men and women who hunt in Wisconsin purchased a waterfowl stamp. Federal authorities estimate that Wisconsin hunters bag approximately 8 percent of the

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ducks and 18 percent of the geese killed by hunters in the 14 states comprising the Mississippi Flyway.

In 1975 an advisory committee was formed to advise and consult in the development of this project. It was comprised of active and retired personnel from the U.S. Fish and Wildlife Service (USFWS) and Wisconsin Department of Natural Resources (WDNR) and leaders from local sportsman's organizations. The study of the waterfowl hunter was selected by this group as the cornerstone of the project because it permitted more scientific evaluation of hunter behavior and the important legal issues and implications associated with the hunting of this key wildlife resource. Based on the advice of the committee, the researchers utilized the 1975 hunting season by conducting a pilot study that field tested the instruments to be used in the research activities. In particular, the researchers were concerned with developing an instrument for the direct observation of hunting behaviors in the field. A major tool to be used in this phase of the study was the so-called "spy blind technique." The researcher-observer waits in an area likely to be visited by the hunter and then, aided by a pair of binoculars or a spotting scope, carefully observes the individual from the time he enters the area until he quits hunting. The instrument used to record the observed data was partially based on the Hunter Performance Survey (HPS) developed by the U.S. Department of the Interior for its studies of waterfowl hunters' behavior in relationship to waterfowl bag limit regulations. The instrument developed for this study expanded on the HPS instrument. It fully describes hunting conditions, hunter behavior, and the number of waterfowl shot, retrieved, and lost. Hunters are watched from points of concealment with the assumption that they would not be aware that their activities were being watched and recorded. The observer was permitted to simulate hunting to avoid arousing hunter suspicion. This research study was designed to determine how the hunter behaves *uninfluenced* by an awareness that someone was watching and recording his performance.

The researchers rejected the concept of a generalized Wisconsin waterfowl hunter or deer hunter. Rather it was hypothesized that not only are individuals attracted to different recreational activities or types of hunting becuase of their personal makeup, but also that different hunting conditions could elicit different behaviors in the same individual. Five waterfowl hunting areas in Wisconsin were selected by WDNR game management personnel as representative of the major waterfowl hunting areas in Wisconsin. The locales ranged from the more highly regulated and hunted state or federal public hunting areas in eastern Wisconsin to the relatively secluded areas of the Upper Mississippi Wildlife Refuge and the marshy woodlands of the Central Wisconsin Wildlife Areas. WDNR personnel continued to help the investigators throughout the study in distributing observations within these five areas based on waterfowl population, hunting methods and conditions, and other variables.

The 1975 pilot study obtained 25 hunter profiles. Based on review and discussion by the advisory group, it was decided to collect data over the next two hunting seasons. Prior to both the 1976 and 1977 waterfowl seasons, students from the La Crosse and Stevens Point campuses of the University of Wisconsin system were selected and trained to do the direct observaton required by the spy blind technique. Students were interviewed as part of a selection procedure and screened for maturity, interest in the project, availability of necessary equipment such as waders, boat and motor, etc. and the appropriate experiences in the out-of-doors. Many of those selected were hunters but some were bird watchers, including two officers of a local Audubon Society chapter. Many of these men and women had important preparation for their work through course work in biology, natural resources, law enforcement or participation in other field research activities which had been conducted by university departments.

To be certified to observe, each student had to complete a 16-hour training session. Approximately half of the training period was devoted to waterfowl identification. It was deemed essential that the students be able to correctly identify the waterfowl being taken from the field by hunters at the end of the hunt. Slides, movies, wing boards, and visits to a local game farm were utilized in these training sessions. The students were tested at the completion of this phase on 20 live ducks including the 12 species most representative of the flyway migration patterns. The students had to correctly identify 95 percent of the ducks by species, and also by sex where a bag differential existed with the regulations (i.e., drake and hen mallards). For those students failing on the initial test, a retest was offered one week later. Approximately 5 percent of students failed both tests and were dropped from the project.

The second phase of this training focussed on the development of field observation skills. Active and retired state and federal wardens conducted this aspect of training and certification. A manual was developed for the study which defined all the terms and procedures being used in the observational format as well as key concepts found in the regulations. Classroom activities included extensive discussions of the waterfowl hunting regulations. For example, considerable time was spent in reviewing what was meant by open water, littering, sky busting, etc. At times even the wardens disagreed on interpretations of the regulations. In these cases, enough time was spent so that the entire group could reach a clear consensus of the interpretation to be used for the study and how hunting behavior was to be described and recorded. In terms of law violations, observers were instructed to take a literal interpretation of the law where a judgement was required. Thus, a violation could be recorded where a warden might not make a field arrest because of the nature of the situation or the difficulty in proving in court that a violation occurred.

Observational competency was evaluated by providing simulated hunts prior to the opening of the season. The students, supervised by wardens, observed mock hunts where individuals acted out a script designed to include the conditions, behaviors, and procedures usually found in waterfowl hunting. Thus, in the simulations, decoys were placed, retrievers worked, blanks fired, and blocks of wood thrown to simulate falling ducks. The hunters carried with them dead ducks (which had been kept in the freezer from the prior season) to enable the observer-trainees to make field identifications and also determine if the hunter had brought in all the "ducks" that had fallen in the simulation.

Reliability and validity checks were conducted in the field during the first days of the hunting season. The retired wardens who had directed the training program took pairs of student researchers into the field where both the warden-trainers and students observed the same hunter. Observational validity for this study was based on the judgement and performance of these retired wardens. Students were permitted no greater than a 10 percent discrepancy between their observations and the data recorded by the wardens. Students were not permitted to work alone in the field unless they had met this criteria for two separate hunts. The six retired wardens continued to observe hunters during the season with their profiles comprising over 20 percent of all the observations made. They also continued to monitor the research activities of the students. For example, the retired wardens were utilized whenever students were asked to observe in unfamiliar areas. Students were placed in spy blinds by the wardens, and their observations spot checked for completeness and accuracy at the end of the day. All profiles were rechecked by the investigators when the students returned from the field; phone calls were also made to a sample of the hunters to verify they had actually been contacted in the field. When a law violation, unethical, or good sportsmanship was observed, the researchers either tape recorded or wrote a detailed description of the behavior and situation in which it occurred. These field notes were all evaluated after the season by two retired wardens for consistency of interpretation. The difference in the rate of violations as observed by the retired wardens and the students was less than two percent (18.6 percent and 20.3 percent respectively).

The second technique utilized in data collections was a field interview conducted by the observer at the completion of the hunt. The researchers introduced themselves to the hunter and presented their credentials as university researchers. At this point they handed the hunter a brochure and made a short oral presentation describing the nature of the research project. The observer-interviewer then conducted a short field interview based on four objectives: (1) to provide some basic demographic data needed for hunter classification; (2) to get an expression about the motivations and satisfactions for the day's hunt; (3) to validate the observations made about the day's bag; and (4) to obtain approval for a post-season interview. During the two hunting seasons through which this research was conducted, over 600 hunters were observed. Approximately 5 percent of the hunters were lost before a field contact could be made; a few hunters (7) were contacted but refused to be interviewed. Complete field data were collected, however, on 596 hunts representing 583 hunters (13 of the hunters were observed a second time).

The third aspect of data collection was a post-season interview conducted in the homes of the hunter-observees after the completion of the hunting season. The interview utilized a 12-page questionnaire including demographic items, self-rating behavior scales, and open-ended questions; the data elicited pertained to formative influences, satisfactions, ethical standards, family conflicts, and rate and rationale for legal violations, among the many variables. The research team recruited 46 psychologists, teachers, and counselors throughout the state to assist with the interview program. All of these men and women were or had been hunters, all had taught, and all had prior training in one to one communication. Thus, any bias these interviewers might have had by training experiences and occupation was consistent with that of the project's directors. These interviewers were then required to participate in a four hour training program that standardized the initial approach and questioning techniques to be used in the interview. To be certified to interview, the trainee had to demonstrate competence, as judged by one of the research directors, while interviewing another trainee with the post-season questionnaire. Forty of 46 candidates were certified by this process. These research associates and the principal investigators then completed home interviews with 442 hunters, or over 75 percent of the 583 hunters observed in the field. The percentage of completion was limited principally by funding restrictions. Less than 5 percent of the hunters refused to cooperate when contacted by a home interviewer.

Results

These research findings described the hunting conditions, antecedents, and hunter attitudes and behaviors that are associated with violators and non-violators as observed in five regions in Wisconsin. To facilitate the reporting of the profile of a violator, the researchers conceptualized the various factors into the following categories: (1) opportunity to violate; (2) hunting methods and intensity; (3) hunting conditions; (4) demographic data, and (5) the attitudes, internal frame of reference and related hunting behaviors associated with waterfowl hunting. The variable, "Did legal violations occur?" was cross tabulated with each variable of the nominal type, and the chi-square test of independence was performed. One-way analysis of variance was used to investigate differences between means for ratio/interval variables. The 5 percent level of confidence is the accepted level of statistical significance in the behavioral sciences; differences up to the 10 percent level have only been reported when they are consistent with the direction of other related findings.

Opportunity To Violate

As can be seen in Table 1, the data consistently indicate that violation of hunting laws and regulations are associated with opportunity to violate. Opportunity begins with birds available to the gun. Observations indicate that the mean number of shooting opportunities for violators (one or more birds in a flight) was 6.7 as compared to a mean of 3.3 for non-violators. The F value of 32.05, based on 1 and 434 degrees of freedom, indicates significant differences ($p < .001$). The number of shots fired is another aspect of hunting opportunity. Violators were observed shooting an average of 11.7 rounds fired per trip in contrast to the 5.4 shots taken by non-violators ($F = 37.08$, $p < .0001$). About one-fourth of the non-violators failed to even fire a shot.

Violators also achieved greater daily and seasonal bags, which apparently reflected both greater opportunity and greater skill. Non-violators averaged only .53 ducks per hunting trip and failed to bag any ducks 73 percent of the time. In contrast, the average daily bag for a violators was .91 and only 55 percent were unsuccessful. ($F = 5.25$, $p < .05$). While a greater percentage of violators were observed shooting a goose, the low numbers of geese bagged makes statistical analysis impractical. This success in bagging game also held true with seasonal bags. Hunters were asked after the season to estimate how many ducks they had shot during the preceding hunting season. Violators reported shooting an average of 17.69 ducks per season as compared to 13.73 for non-violators ($F = 3.60$, $p < .058$). For those who reported shooting no ducks at all, the observed violation rate was 12 percent, and for those who shot between 1 and 5 ducks over the entire season, that violation percentage was 14. In contrast, for hunters who reported shooting more than 20 ducks per season, the violation ratio for the observed hunt was 28 percent. The differences in these distributions are significant ($X^2 = 9.87$,

$p < .05$ for 4 df). There was not a significant difference between the two groups in *times hunted per season*. Violators were apparently more skilled in bagging waterfowl given comparable time spent in the field.

Comparisons of the 1976 and 1977 seasons indicate that waterfowl were more plentiful in 1976. The violation rate on the Mississippi River and the West Central Wisconsin Conservation Areas for the first of the study year was 30.8 percent. While the areas studied in 1976 and 1977 were not exactly comparable, the overall percent of violation in the latter year was only 16.4 (X_2 for these differences is 7.36, $p < .01$ for 1 df).

Environmental conditions also reflect greater opportunity to bag game (and violate). Significantly greater violations occurred when the wind direction was north, south, or southeast than when the wind was from other directions ($X^2 = 22.40, p < .01$ with 7 df). The same was true when the hunter was hunting from open water or stump fields rather than on land or island blinds ($X^2 = 16.14$, $p < .01$ with 4 df). The judgment of wardens, consultants and experienced duck hunters in Wisconsin indicate that these wind directions produce strong winds which, when coupled with open water hunting, produce the best possible shooting opportunities.

Hunt Methods and Intensity

The casual observer has probably noted that waterfowl hunting can result in a sizable outlay of money and time for items such as trap and skeet shooting, specialized equipment, and a retriever. As in most recreational outlets (jogging, fishing, etc.) casual interest oftens turns into an intense, goal directed activity. This results in identification with the sport, which is often accompanied by the acquisition of a uniform or specialized clothing, a distinctive and often exclusive vocabulary, and other unique behaviors. In determining whether intensity was associated with violation, the researchers first asked hunters if they shot trap or skeet before the season. Fifty-eight percent of the violators answered affirmatively as opposed to 44 percent of the non-violators ($X^2 = 4.28, p < .05$ with 1 df). While significant at slightly higher than the .05 level of confidence, larger percentages of violators also belonged to Ducks Unlimited, read technical magazines for information about hunting skills, and prepared a blind before the waterfowl season started. Thirty-seven percent of the violators owned and used a retriever while only 21 percent of the non-violators used a dog ($X^2 = 8.02, p < .01$ with 1 df). However, the quality of the dog they ran was significantly poorer according to observer judgments ($X^2 = 9.77$, $p < .01$ with 2 df). Significantly larger percentages of violators used a duck call while hunting ($X^2 = 3.95, p < .05$ with 1 df) and had camouflaged their boat ($X^2 = 4.51, p < .05$ with 1 df). The consistency of these results lead the investigators to reject the null hypothesis that there are no differences in hunting methods and intensity of involvement in the sport between violators and non-violators.

Hunting Conditions

Data describing the conditions of the hunt were taken by the observers for a number of variables including weather, time, size of party, etc. (Some of these were also judged to be associated with opportunity to violate and were reported above.) One popular scapegoat of Wisconsin hunters is the non-local hunter who comes to prime waterfowl habitat from a distance, and usually from an urban area. The data, however, do not support this assertion. The rate of violation for non-local hunters was 15 percent as compared to 25 percent for those who lived less than 25 miles from where they hunted ($X^2 = 7.12, p < .01$ with 1 df).

Significant differences were also found between those hunting early as opposed to later in the season. During the two waterfowl seasons in which this study was conducted, Wisconsin utilized a split season; a 5-day closed period followed the first two weekends of the season. The rate of violation dropped from 26 percent to 17 percent after the split in the season. ($X = 4.99, p <$ with 1 df).

Table 1. Attributes for which a significant difference exists between violators and non-violators of hunting laws and regulations

Attribute	X^2 or F value	df[a]	p value
Opportunity to Violate			
No. of shooting opportunities	32.05	1,434	.001
No. of shots fired	37.09	1,434	.001
Size of daily bag of ducks	5.25	1,433	.05
Year of hunt	7.36	1	.01
Wind direction	22.40	7	.01
Location of blind	16.04	4	.01
Method–Intensity			
Use of retriever	8.02	1	.01
Quality of dog	9.77	2	.01
Use of duck call	3.94	1	.05
Shoots trap and skeet pre-season	4.26	1	.05
Use of camouflaged boat	4.51	1	.05
Hunting Conditions			
Distance from home	7.12	1	.01
Area of state	15.87	4	.01
Day of week	13.53	6	.05
Day of season	4.99	1	.05
Demographic Factors			
Age	10.04	1,434	.01
Years hunted	6.86	1,433	.01
Behavior, Attitudes and Knowledge			
Positive behavior observed	12.43	1	.01
Ethical violations observed	13.37	1	.001
Satisfaction with daily hunt	8.60	1	.05
Reasons for satisfaction	34.39	7	.01
Attitude towards changing hunter ethics	9.80	1	.01

[a]If only one value is listed for df the test was a Chi-Square test of independence involving the variable "Did Legal Violations Occur". Since this variable consisted of two levels (yes, no), the number of levels of the other variable can be ascertained by adding 1 to the df listed. If two values are listed for df, the test was a One-Way ANOVA which compares the means of violators and non-violators.

Violations were also analyzed by day of the week. The percentage of hunters violating the law was significantly greater on Fridays and on weekends. The 36 percent rate of violation was highest on Fridays ($X^2 = 13.54, p < .05$ with 6 df). Further analysis of those hunting on Friday indicated that they were also more likely to be local hunters. Hunters judged to be intensive by the observers reported in the interviews that they do try to get a jump on the expected influx of non-locals who drive long distances for the weekend hunting.

The five different areas of the state surveyed offered both different opportunities and different conditions to the hunter. When comparisons were made between those hunters who did not bag any birds, significantly greater percentages of violation still occured on the Mississippi River and in the forested, marshly, public lands of central Wisconsin. ($X^2 = 16.36, p < .01$ with 4 df). Hunting areas with the lowest violation were state or federally owned hunting areas in the more highly populated eastern sections of the state. These areas often had personnel making daily bag checks, and their smaller size made regulation and control by wardens more possible. The data also suggest that hunters who hunt alone in these areas are less likely to violate than those hunting with a group. Ethical violations, for example, were significantly greater for parties of five or more hunters as hunters. Poor sportsmanship was observed in 57 percent of the hunters who hunted in groups of this size as compared to 30.4 percent and 27.5 percent where the hunter was alone or with a partner ($X^2 = 13.2, p < .05$ with 4 df).

Demographic

Comparisons were made between the age and the number of years hunted by these subjects. The mean age for violators was 27.75 as compared to 33.33 for non-violators. The F value of 10.038 based on 1 and 434 degrees of freedom indicates significant differences ($p < .01$). Comparably the mean number of years hunted by violators was 11.55 as opposed to 15.66 for non-violators. ($X^2 = 6{,}86$, $p < .01$). Further analysis of the data indicated that the rate of violation dropped considerably for those who had hunted more than 20 years.

Attitudes and Ethics

The disposition to violate extended to other hunting behaviors and attitudes as well. Thirty-one percent of the violators were judged by the observer teams to have hunted unethically. These behaviors were principally shooting at ducks out of range and crowding of other hunters ($X^2 = 13.37, p < .001$ with 1 df). Positive behaviors were also noted by the research teams. Thirty-nine percent of the violators were observed displaying good sportsmanship as compared to 61 percent of the non-violators ($X^2 = 12.43, p < .001$ with 1 df).

Hunters were asked to rate their satisfaction for the day's hunt on a four-point scale: excellent, good, fair, and poor. Violators were significantly more likely to report satisfaction with their day's hunt. For example, 39 percent of them declared they had a poor day as compared to 51 percent of the non-violators ($X^2 = 8.60$, $p < .05$ with 3 df). When asked what was satisfying about their hunt, they were more likely to indicate that bag, shooting opportunities and competition with other hunters were the bases for this satisfaction. Non-violators, in contrast, reported that companionship, seeing game, and an opportunity to observe nature were the most satisfying ingredients of their hunt ($X^2 = 34.39, p < .001$ with 7 df). Hunters were also asked in the post-season interview how ethics could be improved. Violators were more likely to indicate that hunting ethics could not be changed. Non-violators, however, were more optimistic and suggested that laws and peer group pressure were factors likely to improve hunter ethics ($X^2 = 9.80, p < .01$ with 1 df).

To evaluate the internal frame of reference of the waterfowl hunters, a 16-item Likert-type attitude measure was given to the individual in the home interview. He was asked to rate each of 16 hunting conditions on a 5-point scale in terms of his own *tendency* to violate (i.e., would never violate = 1; would violate = 5). As can be seen in Table 2, that item which has the lowest mean ($\overline{X}$) rating, and indicates the lowest likelihood of violation is hunting when your children are present. Those other items rated in the lower half by ranked mean score suggest unfamiliarity and insecurity; when the hunter is on a public hunting ground ($\overline{X} = 1.26$), does not know the owner of the land ($\overline{X} = 1.27$), is hunting out of state ($\overline{X} = 1.31$), or is a long distance from home ($\overline{X} = 1.41$), he has a low tendency to violate according to self report. Opening day ($\overline{X} = 1.37$) and heavy hunting pressure ($\overline{X} = 1.36$) are also more inhibiting factors. Those factors with the highest mean value (i.e., the greatest likelihood of violation) suggest security and knowledge of the hunting territory: self-ownership ($\overline{X} = 2.01$); low probability of getting caught ($\overline{X} = 1.97$); hunting alone ($\overline{X} = 1.73$) and knowing the owner of the land ($\overline{X} = 1.66$).

To determine if a difference exits among the groups with respect to the relative importance of each item, the means were ranked and the rank orders were compared. The Spearman rank order correlation coefficient of .938 corresponds to a t value of 10.1462 with 14 df ($p = .001$) indicating a significant difference in the rank orders. The greatest difference in rank order corresponds to the item "late in the season" which was ranked first by the violators and fourth by the non-violators.

Discussion

This study was not initiated as an attempt to either indict or exonerate hunters. It does not surprise the researchers that some hunters were observed violating the law. They assumed that most hunters have at least accidentally broken a game law at some point in their lives. As stated earlier, an understanding of who violates and under what conditions that violation occurred was seen as an essential first step if hunting was to be improved through regulation and education. It does seem significant that hunters not only tolerated this research within their ranks (the investigators are hunters themselves), but responded to it so positively, as indicated by the high percentage of hunters who cooperated in both the field and the home interviews. It's probable that only hunters themselves could have conducted this research project. Law enforcement personnel from the Wisconsin Department of Natural Resources have been quick to acknowledge that they could not have gained the acceptance and cooperation of hunters in many of the aspects of this project.

The explanations of this positive response are many. Certainly hunters are deeply bothered by the behavior of unethical hunters. When asked what dissatisfying experiences they had as a hunter, almost 3 out of 4 hunters cited the ethics and behaviors of other hunters towards either the wildlife resource or other hunt-

Table 2. Ranking and mean response of tendency to violate under selected hunting conditions.

	Combined	Violators	Non-violators
	Rank (Mean)	Rank (Mean)	Rank (Mean)
Self ownership of land	1 (2.01)	2 (2.1905)	1 (1.9765)
Low probability of getting caught	2 (1.97)	3 (2.0690)	2 (1.9535)
Game abundant	3 (1.88)	4 (2.0349)	3 (1.8584)
Late in the season	4 (1.86)	1 (2.1954)	4 (1.7849)
Hunting alone–little pressure from others	5 (1.73)	7 (1.8161)	5 (1.7151)
Don't believe the regulation is necessary	6 (1.70)	6 (1.8506)	6 (1.6667)
You personally know the owner of the land	7 (1.66)	5 (1.8941)	7 (1.5982)
Game scarce	8 (1.50)	8 (1.6322)	8 (1.4824)
Long distance from home	9 (1.41)	11 (1.5632)	10 (1.3797)
Alcohol usage	10 (1.41)	12 (1.4943)	9 (1.3942)
Opening day	11 (1.37)	10 (1.5663)	11 (1.3144)
Heavy hunting pressure	12 (1.36)	9 (1.6092)	12 (1.3043)
Out of state	13 (1.31)	13 (1.3953)	13 (1.2841)
You do not know the owner of the land	14 (1.27)	14 (1.3953)	15 (1.2370)
Public hunting grounds	15 (1.26)	15 (1.3218)	14 (1.2399)
Your children are present	16 (1.10)	16 (1.0952)	16 (1.0979)

ers. There was also an anxiety about the goals and activities of anti-hunting and anti-gun activists throughout the country. The increased posting of land, at least in Wisconsin, has also carried a strong message to hunters about attitudes landowners may have about hunters and hunting, and the hunter behavior that elicits this kind of hostility. While their critics may point out that hunters are late in responding to problems that have existed for years, this is not unusual in our crisis-oriented society. More importantly, hunters are ready and motivated to take responsibility for improving the quality of their sport.

The results of this study seem to validate many of the assumptions and hypotheses that the investigators had about hunting and hunters. Psychologists generally believe that all behavior is an expression of the basic personality and values of the individual and those groups or segments of the society with which he identifies. Hunting is no exception. The data indicates that a violating waterfowl hunter frequently is an individual who is deeply involved and dedicated to hunting. The intensity of his motivation and participation includes preseasonal activities as well as hunting itself. This type of hunter is a goal-oriented individual who may reflect many of the economic, educational, or recreational practices of our society—the end justifying the means. This intensity and dedication as observed in certain hunters had led the investigators to conceptualize five developmental stages of waterfowling. It is theorized that almost all hunters proceed through these stages, and that growth from one stage to the other may depend upon the passage of time and the need for fulfilling experiences as prerequisites to that movement. The first step in this developmental sequence is termed the *shooter stage*. The beginning hunter apparently needs to pull the trigger and test out the capability of his weapon. He may shoot at blackbirds, signs, insulators, tin cans, or a hawk. Satisfying that need, the hunter moves to a *limiting-out stage* where bagging game becomes primary and the hunter measures success by the numbers of birds or animals shot. From this developmental level, he seems to move to a third or *trophy stage*. With waterfowl hunting, this could mean selectivity in only shooting "green heads" or those ducks and geese that have definite status. The fourth or *method stage* follows. It is characterized by an intensity or almost religious fervor about waterfowl hunting. This hunter usually has all of the specialized equipment: decoys, calls, camouflaged boat, retriever, etc. Hunting has become one of the most important dimensions of his life. It's what he does best, and he lives for the opportunity to practice that expertise. And as the results indicate, many of these dedicated and experienced hunters have not accepted those self-imposed, voluntary controls which Leopold felt marked the ethical hunter. Finally, the research findings indicate a "mellowing out" stage which apparently many hunters do not reach until about 40 years of age and after many years of hunting experience. At this point, the hunter finds satisfaction in the total hunting experience. This hunter is no longer a shooter or hunter but has reached the waterfowler stage. There is a breadth of satisfaction available to him, drawn from contacts with nature, familiar and treasured surroundings, and other important hunting associations. Bagging game seems more symbolic than essential to the hunting process.

The implications for education are many. If these stages of development have any validity, experiences should be created or substituted to help the hunter move through these stages quickly and without ethical violations. For example, individual hunters report that trap and skeet shooting and range firing both were effective in moving them as beginning hunters through the first or *shooting stage* without necessitating the shooting of nongame species or property.

Of course, not all serious, intense hunters are violators. Just as there are important individual differences within the ranks of waterfowl hunters, so would there be differences in ethical behavior among hunters who would fall into the stages described above. The results would also support the hypothesis that individual differences exist within the same individual depending on whether he is hunting in familiar territory within a few miles of home, or hunting out of state. He will hunt differently when in the company of a large or competitive peer group as opposed to hunting with his own children. Those who would manage or educate hunters should remember that hunting is no different from other forms of behavior in that many influences, factors, and conditions determine exactly how a particular hunter expresses his values and attitudes in behavior.

If individual differences are important in understanding hunting behaviors, it would be not less important to stress that there is no single answer to improving hunter ethics. Certainly improved regulations and law enforcement are a partial answer. Hunters confided in the post-season interviews that the personality and attitudes of the local conservation wardens were important variables in whether or not they violated. If they respected that individual, they chose not to violate. Others indicated that bag limits and high game population forecasts pushed them towards violation. Good sportsmen, as observed in this study, were also significantly more likely to call for revision of the point system because they felt that aspects of those regulations encouraged violations (resequencing, because the sequence in which waterfowl are taken can be a factor in when the point limit is reached).

The ultimate answer to improving hunter responsibilities will be found in education. History indicates that morality or ethics cannot be legislated; there is little support for this carrot and stick approach to behavior management. The hunters interviewed for this study rated (1) becoming responsible and involved with wildlife, (2) training and hunting skills, and (3) participation in adult hunter education courses as having greater effectiveness on improving their own sportsmanship than fines and sentences. Many have frankly stated that fines do not bother them, but that they do fear the possibility that their names will appear in the paper as violators. In other words, social approval or disapproval is what carries weight. Differences in conformity to moral and ethical standards when viewed comparatively from society to society gives further insight into this attitude. Even poverty stricken societies can be law abiding when citizens themselves take responsibility for each other and become directly involved in demanding legal and ethical behaviors of other members. The implications for hunting or any other recreational activity in our society seem obvious. Hunters themselves must take the ultimate responsibility for setting standards and hunters themselves must demand that others in their rank conform to those ethical values.

Thus, the models for improving hunter education being recommended by this paper stress education rather than regulation, identification as opposed to indoctrination. The basic mechanism of socialization in our society is identification; we behave in certain ways because we want the approval of our parents or our peers.

Aldo Leopold stressed that a responsible hunter is one who imposed restrictions upon himself as he went into the field. But this voluntary adherence to a code can better be achieved through identification with the positive values of other good sportsmen than through any extrinsic system of rewards and punishments. In order to predict how a man will behave, ask not what he knows but what he values. Values, however, cannot be taught like parts of a gun. In fact, they are caught, not taught. Kohlberg (1971) points out that to *effectively* raise the individual from one level of ethical behavior to a higher one, requires that the person become involved with an individual (or group) already at that higher level of development. The person (hunter) will conform to the higher values to gain approval. Even the individual without a conscience will act ethically to achieve and maintain a place in the group. By implication, the group (in this case, responsible hunters) cannot afford to be a silent majority. It's time hunters become activists in demanding ethical behaviors of their peers, and in recognizing and reinforcing quality of behavior rather than quantity of bag.

The final recommendations of this paper deal with education. Hunters themselves sensed the importance of education. When asked how hunting ethics could be improved, almost half of these subjects indicated education; these comments were evenly divided between those advocating better programs for juvenile hunters and those calling for newer, improved adult education.

The results of this study, however, raise questions about educational content and methods. Accepting that principle responsibility of all hunters and of hunter education is to the wildlife resource itself, is knowledge or information about that wildlife resource alone enough to improve behavior? Others findings of this study indicate no. Scores on a 16 point waterfowl identification quiz, given as part of the post-season interview, indicated that the *unethical* hunters in this study had significantly higher scores and apparently more knowledge about waterfowl characteristics than responsible hunters. Knowledge of waterfowl characteristics was not a deterrent to ethical violators.

Kellert's (1976) findings on the attitudes of humans towards animals point to a different direction for hunter education. He found that one group of hunters fell into a group he described as naturalistic. These hunters demonstrate strong feelings of responsibility and compassion towards wildlife and typically were deeply involved with wildlife. Hunting for these persons provided a means to communicate and become deeply involved with nature. Involvement is the important concept here. Effective hunter education will involve sportsmen directly with wildlife programs, and hunter education itself. Look at any community program and ask whether a greater sense of stewardship develops in those who donate money or those who actively plan and participate in programming.

In summary, the authors suggest that to improve hunter ethics and responsibility (1) change will develop more from education than regulations or management of hunting conditions; (2) hunters themselves must take the primary responsibility by example and communication of high standards to other hunters; and (3) hunter education, to be effective, must provide both information and the opportunity for hunters to become directly involved with wildlife and educational programs.

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Incorporating Society's Concerns into Trapping Systems: Progress on an Immediate Challenge

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One effect of intensified urbanization, and the increasing distance of most people from the basic food and clothing production processes, has been the development of a philosophy towards living things that is based primarily upon emotion. This philosophy is no doubt encouraged by the availability of milk in cartons, meat ready-cut and wrapped in plastic, and the introduction of wild animals into the domestic environment via the television screen. However, that urbanization has appeared to tame and disinfect all those slightly unpleasant things that are inescapably necessary for man's survival is, of course, largely an illusion.

Most people nowadays live in cities; the public is largely an urban public. The intensity of public opinion has a profound effect upon government policy and the legislative process; and the combined voice of thousands of individuals speaking from within the confines of a few square miles sounds very loud indeed.

To people used to dealing with animals in a practical sense—those who farm in order to provide food for the cities, for example—some of the views printed daily in the letter columns of the larger newspapers appear incomprehensible. And there truly is little logic in people's becoming consumed with rage at the idea of killing helpless baby seals, while at the same time accepting the fact of eating and wearing products from slaughtered and equally helpless baby sheep, cows and pigs.

However, it is unrealistic to believe that all the changes demanded by urban society are frivolous. There have always been abuses connected with the use of animals; and it has been these which historically have triggered the major reforms in the field of animal welfare. The need for the development of stress-free trapping systems is a case in point. It has never been a problem perceived solely by those living in the city. Trappers who at some stage in their trapping career have come to see trapped animals as worthy of compassion are many, and their stories are well documented. In some individuals such a change in attitude has led to the abandonment of trapping altogether; in others, it has engendered a desire to invent better capture methods.

Yet, trappers both individually and collectively could not, and cannot, put sufficient pressure on governments to obtain fiscal support for trap development. In consequence, the subject of humane trapping for years remained very much a minor item. It concerned those actively involved in the field, such as government personnel, biologists and trappers; and it also attracted the dogged perseverance of a few individuals from other walks of society, those marginally dotty idealists whose walk is always slightly out of step but who are surprisingly often the active harbingers of social change. And it was, in the final analysis, the voice of public opinion that provided the impetus for government to become seriously involved in finding solutions.

At this point, it is as well to remark firmly that trapping can be, and has been, done in many unnecessarily barbarous ways. It can also be done in ways which, in terms of allowing the animal either a quick death or minimum stress until death, can certainly be called humane; humane in the same context that animal welfare agencies call the euthanasia of cats and dogs, and the live-trapping of nuisance animals, "humane;" and humane in the sense that slaughterhouses (whose products end up on the antiseptic shelves of supermarkets) call the slaughter of domestic food animals "humane."

In the humane trapping context, early perception of the problem on this continent was perhaps simplistic. It was, essentially, that trapping should be banned. However, the unrealistic nature of this particular goal did become evident. A movement to ignore the basic philosophic question of whether to trap or not to trap culminated in a concentrated effort to evaluate and develop actual humane traps. Initiated in 1968, the Humane Trap Development Committee (HTDC) of the Canadian Federation of Humane Societies (CFHS) reflected a volunteer effort to apply modern scientific methods to the development of humane traps. Although it was a committee of the CFHS, the HTDC was in fact also sponsored by the Canadian Association for Humane Trapping (CAHT) and the Association for the Protection of Furbearing Animals (APFA), with CAHT providing the main administrative guidance. The HTDC research was in two parts; biological, where an attempt was made to determine kill thresholds for certain furbearers, and mechanical, where the kinematic properties of traps were evaluated. The work, done at two Ontario universities, was funded by donation and bequest. Of approximately $60,000 that was collected, $6,700 came from provincial government sources.

However the work was slow, and to the people involved in funding and administering it the lack of government support for what was in essence an attempt to solve a national problem was very discouraging. In 1972, therefore, after an earlier suggestion made to the Canada Fur Council that modern media tactics would be used if necessary had not been taken seriously, CAHT engaged in a short, very effective publicity campaign. The centre of this was the film "They Take so Long to Die" which used controversial footage shot by an Alberta trapper-photographer. Some of the animals were filmed in a compound; and some were put into the traps before being filmed (although one should note that not all CAHT principals involved in the purchase of the footage were aware that this had been the case).

The film, which certainly does show what can happen when animals are leg-trapped, was graphic and gory, and the public in Canada responded with predictable horror. Contacts in Europe also publicized the "carnage on Canada's traplines," and the total result was enough to encourage government to consider the apportionment of sufficient funds to attempt to find solutions.

In 1973, the Federal Provincial Committee for Humane Trapping was formed as a committee of Canada's Federal Provincial Wildlife Conference. Its mandate was stated as ". . . over a period of five years, to co-ordinate and encourage the development of humane trapping methods and devices; and to recommend to the provinces, traps and trapping techniques which will provide, insofar as the state of the science and the art will allow, the greatest "humaneness" in holding or killing furbearing animals."

With this assured commitment of solid government support, the CAHT withdrew its film from global circulation. The HTDC offered to the new committee all the research findings that were not affected by patent limitations. Both the CAHT and the Canadian Federation of Humane Societies gave the new committee qualified, but enthusiastic, support.

Ironically, this marked the beginning of a serious difference in the approaches of the two humane trapping groups, CAHT and the APFA. The APFA was firmly against any kind of reliance upon government. It maintained that the public had a right to be involved in the direction of research; and it felt excluded enough to initiate the production of a new film, using the old footage. This was to be called "Canada's Shame," and it is still available. CAHT and the CFHS, on the other hand, felt that government deserved some uninterrupted time in which it could work on the problem. They also considered that certain fences, which had been thoroughly trampled during the preceding publicity, needed to be mended if a concerted and effective search for humane trapping systems could be possible. The respite caused by the cessation of publicity was used to consolidate efforts in areas such as trapper education. And it should perhaps be remarked that the termination of the CAHT's sensational public relations campaign cut both membership and donations, while the intensification of the APFA effort certainly improved both the financial situation and the membership list of that group.

Having made a commitment toward a national effort to find more humane trapping systems, the Canadian governmental jurisdictions involved moved with unbureaucratic speed. The original five-man committee, by April of 1974 had worked out funding, budgets, and broad and specific goals, and had hired a coordinator. The committee's five-year program was developed with an initial projected budget of $366,000. Contributions by the various jurisdictions were based on the average annual revenue to trappers from fur sales in each jurisdiction over the previous three years; and the contribution from the federal Department of Indian and Northern Affairs was set at approximately 25 percent of the total. The total budget figure did not indicate the very substantial contributions made by the various jurisdictions in such areas as travel, field testing, and trapper education; and neither did it include the important basic work which was to be carried out by the Canadian Wildlife Service (CWS). CWS was already committed to develop trap standards for inclusion in regulations pertaining to certain federal lands (those withdrawn for wildlife purposes) and this work seemed to provide a good base for the committee's main trap testing program. Thus, CWS undertook to arrange and fund both a biological testing program and a mechanical evaluation program, which would simultaneously attempt to evaluate traps and formalize the ways in which they would be evaluated.

These programs, which were to be undertaken by bodies of legally recognized standing, constituted the main trap testing program of the new committee, which was by now being referred to as the Federal Provincial Committee for Humane Trapping (FPCHT). CWS also offered to contribute accounting, financial and other administrative and advisory services.

The first year and a half or so of the committee's mandate was generally concerned with familiarizing the first coordinator with the problem, and setting up basic procedures such as the acceptance of devices, the establishment of a patent advisory service, and arranging photographic, specifications and drawing services. In November of 1975, a new coordinator was hired. One of the first things he did was to form the Scientific and Technical Subcommittee. This subcommittee represented the beginning of a more open relationship between the FPCHT, and both humane societies and the academic world. Serving on the subcommittee at that time were a trapper, two biologists, a mechanical engineer and a humane society representative. (Since then, it has lost a biologist and gained a veterinary pathologist). These men were to make a preliminary subjective analysis of each trap submitted to the FPCHT; and later they were to take the lead in advising on the details of research. They selected the seven most suitable traps for inclusion in the CWS testing programs, which got underway in 1976.

In addition to the biological and mechanical testing, CWS also undertook to arrange research on "Determination of Criteria for the Evaluation of Humane Traps." This work was to establish kill thresholds for four major furbearing species. A kill threshold is the lowest level of energy which, when applied to an animal of a given species, will predictably kill most animals within that species. The idea was to provide tables which would outline the various mechanical criteria traps must meet in order to be able to kill the animals for which they were designed.

For details of this and the other CWS work I refer you to the CWS *Progress Notes,* #86, August 1978, titled "Review of progress in development and testing of humane animal traps."

However, when the mechanical and biological test work and the "criteria study" were finished, so unfortunately was the research involvement of CWS. To the FPCHT, faced with the continuing submission of new traps and no means of granting these anything more than a preliminary evaluation, this posed something of a problem. Since the initial FPCHT funding arrangements concerned the provision of coordinating and administrative facilities only, a new look had to be taken at both the funding and the functions of the FPCHT. At meetings held in early 1977, therefore, it was agreed to seek additional money from the contributing jurisdictions. This was granted. Subsequently, new research, under the direct administration of the FPCHT, was set up in three areas. The first and most important concerned provisions for the development and testing of actual trapping devices. The others consisted of a feasibility study regarding the investigation of terminal dives in semi-aquatic furbearers, and a study on the effects of laterally-delivered blows. These two studies are complete and the findings are currently being interpreted.

The mechanical evaluation and development program is ongoing. It is an essential program because most inventors submitting devices to us generally do not have the facilities for the continual experimentation and redesign necessary to come up with finalized devices. The system is tripartite, with mechanical evaluation giving the measurements of a trap's effective energies, mechanical development providing engineering and design input, and approach testing allowing an assessment of the behavior of the animal in relation to the trap. Serious problems were encountered in setting up the approach study; and early in 1978 outside funding was sought and the project expanded to make up for lost time. The study consists of wild furbearers approaching and entering traps that are wired in set position in a simulated natural environment. Videotape recordings made during the approaches are analyzed. The work allows us to assess, and design for, accurate strike location.

When a trap meets the basic criteria of providing simplicity of operation, sufficient energy to kill the target species, and a predictable strike location, it is recommended for controlled field testing. Here the approach study facilities are used, but the trap is allowed to kill the animal. Figure 1 outlines the progress of a trap through the FPCHT evaluation and development system.

One of the problems encountered in the early CWS mechanical and biological tests continued to plague the FPCHT throughout its work. The problem lay in dealing with the practical assessment and development of traps while at the same

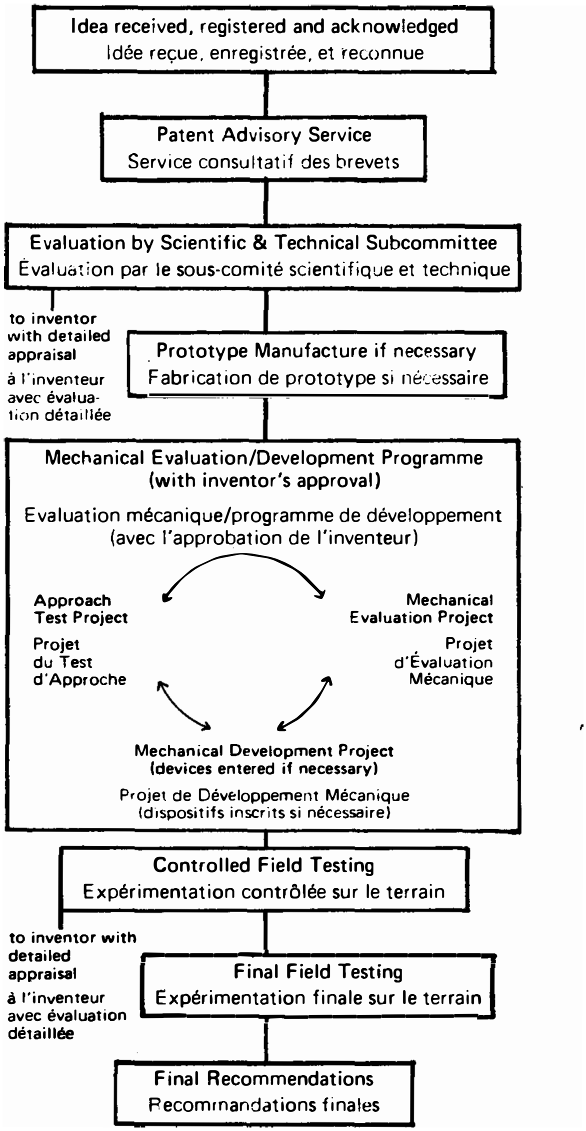

Figure 1. Flow chart of a trapping device's journey through the FPCHT's evaluation and development system.

time working out the basics of how and why they operate. We obviously can design traps to kill any animal when we know what impact and clamping forces are needed to kill that animal, and know enough of the animal's behavior in relation to the trap's configuration to be able to predict where it will be hit when the trap is triggered. However, we have to continue to evaluate, modify and develop traps concurrent with our basic research; and this means that certain judgements are still unavoidably intuitive.

Another problem is of course the common one of doing research that only poses more questions. For example, how far can we go in the evaluation of stress in aquatic furbearers? We wanted to determine whether or not these animals die from narcosis, or by drowning; however the results of research to date are equivocal, and we are of course left with more questions than when we started. Drowning in semi-aquatic furbearers is a new research area, and we have had to start from the beginning, attempting first to develop the technology needed to conduct the research. And when we do know about the physiology of the four species involved, then we still must determine the best methods for their capture.

Much of the criteria study was also virtually pioneering work; again, there are aspects relating to the effects of clamping force which need to be answered. And so it goes.

It would be easy to run live animals through individual traps, make a subjective analysis on the stress effected (by rating the animals' struggling and vocalizations) and then develop traps on the basis of using more animals to prove each modification. In fact, attempts have been made through the years to do this. However, historically, the value of such efforts has been questionable, and the moral and ethical questions posed by such exercises have been considerable. Society, while demanding that a humane death for furbearers be found, also (and with some justification) demands humane treatment for animals used in research. The FPCHT's way around this apparent Catch-22 has been to research the wider aspects, while building in as many safeguards as possible before actually testing traps upon unanaesthetised animals.

In a sense, the choice of five years as the initial mandate period was unfortunate. It was predicated on a perception of the problem that was too limited; it did not allow for the expanding complexity of providing answers to the most basic questions. It certainly did not allow for the initial period of relative inactivity in the area of baseline research.

Last year, therefore, the committee requested and was granted an additional two years in which to attempt to make a more complete assessment of what constitute the best humane trapping systems in Canada. This was a recognition by the contributing jurisdictions that the work is important and should continue uninterrupted. It is important in terms of solving a problem of national conscience; and it is vital in terms of protecting the economic viability of an industry.

Currently, the FPCHT, with the guidance and assistance of its Scientific and Technical Subcommittee, is setting up research activities for the next two years. Planned are a continuation of the investigation of terminal dives in semi-aquatic furbearers; a study on snares, with particular reference to power snares; a study on kill thresholds in five more species; research on the effects of clamping force; and, of course, a continuation of the mechanical evaluation and development program.

At the end of the FPCHT's extended mandate, it is expected that recommendations will be made about complete humane trapping systems. It is moreover expected that the complexity of the problem will be matched by the complexity ofthe solutions. And we cannot expect that all solutions will have been found, even with an extension of two more years. National standards for humane traps are already in the process of being written, and these may be incorporated into law by the various Canadian jurisdictions if they so chose. Traps will ever offer only the potential for humaneness; realization of that potential will be up to the trapper. Trapper education is critical, both here and in the area of getting new ideas and techniques accepted. Trapping conditions vary considerably over Canada; jurisdictions will have to continue in their efforts to find the best and most efficient trapping techniques for their own conditions. Certainly, trappers will keep experimenting with the new ideas, and one can predict that improvements will continue to be made. An agency will have to be designated to test other devices which are developed later. In short, the demise of the FPCHT will not mean the end of trapping innovation.

Unfortunately, a continued and intensified effort of this kind on the part of government does not get many gold stars from the public. We are expecting our protagonists to be heavily critical of the work already done, and to question the need for additional research. This attitude is understandable when one goes back to the simplistic emotional rationale: the problem is simple—the leghold trap; and the answer is also simple—ban the leghold trap! Those who become able to see the question in its wider context often get assimilated into the quest for more realistic answers, and in consequence become as boring as government in the publicity game.

We know that new media campaigns are being planned. One group has been collecting money for yet another film, containing footage "shot on the trapline," and it is expected that this will be more sensational than its predecessors. The ethics of staging such a film are inconsequential against a firm conviction that "the public must be made aware of the problem."

One would like to believe that when trapping is done humanely, as it can be, members of the public might accept its products in the way that they accept a steak dinner. One prefers to think that people are not totally vulnerable to the expensive media campaigns of what can all too often be classified as illogical, emotional and zealous bands of aggressive pseudo-vegetarians.

We can design humane traps. We believe it is possible to formulate trapping systems within which all furbearing species can be taken with a minimum amount of stress. Our governments concur that the work is necessary, and support it. The question now may well be whether this is what the public really wants, or whether it is prepared to be swayed by the next, inevitable, appeal to both its emotions and its purse.

Political Assault on Wildlife Management: Is There a Defense?

James W. Goodrich
The Wildlife Legislative Fund of America

Every four years a $30–50 million war chest is put together for the important purpose of running campaigns to elect the President of the United States.

Every year in the United States $30–50 million is collected and spent for campaigns to stop hunting, trapping and fishing and to close down wildlife management.

The money is collected and spent by a group of fanatics who are alternately known as "preservationists," or "animal rightists" or, more to the point, the "antis"—so-called because they are anti-hunting, anti-fishing, anti-trapping, anti-modern farm methods, anti-fur industry and, especially, anti-wildlife management.

How the Antis Work

A 1971 *Field and Stream* article titled "Our Outspoken Opposition," by Gary Sitton, concluded: "The opposition (anti movement) is far from disorganized, and at some point in the future, coordinated action with some hefty sacks of cash just might be possible."

The Future is Now

Our research-education-litigation arm, The Wildlife Conservation Fund of America, recently completed a major research project, the purpose of which was to measure the current threat of the anti movement and to identify patterns of activity of the organizations involved. The study affirmed these major propositions:

1. The target objectives of the various anti groups are very similar.
2. They do indeed join forces, as the 1977 anti-trapping campaign in Ohio demonstrated.
3. Their revenues have increased to an extraordinary extent.

They Raise $30–50 Million Yearly

The principal anti organizations have become highly sophisticated fund raisers. They are especially expert at selling emotion. Save the baby seal. Save the polar bear. Save the dolphin. Stop cruelty. There is a very heavy drive now for bequests. Windfalls in the millions of dollars, with few strings attached, will enable them to reach their objectives more quickly. Some studies have put their annual revenues in the $40–50 million range. The evidence we've seen indicates a somewhat more modest annual aggregate income of about $30 million. Either figure, however, represents some very "hefty sacks of cash."

Much of it is used for ads to raise more funds to buy more ads to raise more funds.

Antis are Excellent Propagandists

Propaganda is another important use. On their IRS forms, the anti groups call it "humane education." They understand the media appeal of animal horror stories and of literary and show business personalities like Cleveland Amory, Mary Tyler Moore and Brigitte Bardot who frequently are the "expert spokesmen." That none of these people are qualified in any field even remotely connected with wildlife biology or wildlife management has been no handicap.

In fact, the anti-groups consistently parade on the edge of the truth and often create mammoth hoaxes in their propaganda program. In October 1978, for example, the International League for Animal Rights mousetrapped the Associated Press and other worldwide news agencies by ingeniously planting the false story in Paris that UNESCO—the United Nations Educational, Scientific and Cultural Organization—had adopted an "animal bill of rights." One Associated Press story went on to say that it would "become UN law by 1980." The story won prominent attention in daily newspapers all over the United States and around the world.

Our organization learned long ago never to take at face value anything that comes from the anti camp. We contacted UNESCO headquarters. UNESCO had nothing to do with it. The United Nations had nothing to do with it. The only connection between the "animal bill of rights" and UNESCO, as UNESCO spokesman Joseph A. Mahan told the Wildlife Legislative Fund of America president, James H. Glass, was that "it [the International League for Animal Rights] did rent meeting quarters in the UNESCO building in Paris and from there released its announcement."

We thought we had seen everything when the International Fund for Animal Welfare tried to raise money to save the sled dogs of Greenland, claiming they were being hanged for fur—based on an admitted hoax by a Swedish journalist. Actually, the main theme of most of the anti organizations is a falsehood—the implication that hunters and trappers endanger species, and that only they, the "animal rightists," are the protectors of species by opposing what they consider to be cruelty to individual animals.

The tragedy in this is that millions of dollars will be collected by the antis, internationally, based on such false information.

Antis Invade Schools

The very "hefty sacks of cash" the antis pick up every year also are used to get their point of view firmly planted in the minds of children. They are deliberately working to raise a generation of children—today's children—who will oppose hunting, fishing, trapping, what they call "factory farming," the research use of laboratory animals, the fur industry and wildlife management. The anti groups expect a pay-off in 10 to 20 years, by which time, the International League for Animal Rights has proclaimed, "hunting for sport will be forbidden in civilized countries."

The "educational" material produced by the anti groups *is* in the public schools. Their material is literally welcomed by the schools because our side has yet to challenge it and has yet to provide the real wildlife management story in the forms that teachers can readily use. One very widely used booklet tells children to persuade their parents not to fish or, if they must fish, to use artificial bait because "worms have feelings, too."

Of the major anti groups, the Humane Society of the United States (HSUS) probably is doing the most effective propaganda job with children and with the schools. Therefore, in our view, the HSUS probably is the greatest threat to wildlife management in the long haul. To accomplish its "education" objectives, the HSUS has at least three sub-groups at work. The National Association for the Advancement of Humane Education reaches teachers and school administrators with teaching seminars and educational materials. The Norma Terris Humane Education Center also produces seminars for teachers and audio-visual aids and education kits for use in the schools. KIND, the HSUS membership organization for young people, is divided into three age groups, with special materials developed for each age group.

Antis Bombard Legislatures, Courts

Another key purpose for which the antis use their very considerable wealth is to directly influence public policy: to try to reach their objectives by legislation and litigation.

Some of the more conspicuous efforts center on campaigns to stop trapping, enforce "animal rights," prohibit hunting on public lands, stop bowhunting, stop hunting with dogs, stop the laboratory use of animals and, of course, declare every creature that swims, crawls, runs and flies to be an endangered species.

The anti-trapping crusade continues to be a very favorite strategy and is stronger than ever despite the antis' enormous setback in Ohio in 1977. Anti-trapping legislation has been introduced in numerous state legislatures this year. Because the anti-trapping drive is the opening wedge of the total anti program, The Wildlife Legislative Fund of America watches anti-trapping activities very closely. Already in 1979 our organization has helped to block anti-trapping bills in several states, including New Jersey and Georgia.

The concept of "animal rights" appears to be on the ascendency with the antis and may well become their dominant theme in the next few years. In February 1979, eighteen California legislators co-authored a resolution creating a "Bill of Rights" for California animals. The antis frequently extend this concept to livestock and poultry as they promote legislation to require farm sanitation techniques that would be practical only in a nursing home for human beings.

Anti's Special Target is Wildlife Management

There is one target that is very special: wildlife management. Never lose sight of the fact that the ultimate objective of the anti organizations is to stop the taking of wildlife by any means, anywhere—and the wildlife manager is in the way. From their view, the wildlife manager has too much autonomy, too much money and too much power over habitat and hunting-fishing-trapping rights.

If these folks have their way: license fee money will go straight into the state general treasuries; the Pittman-Robertson and Dingell-Johnson funds will be diverted to the antis' own purposes; antis will control the boards and commissions, and the autonomy of the fish and wildlife agencies will be destroyed. In short, the professional wildlife manager will be out of a job.

The antis can get very nasty in some of their printed comments about wildlife management—comments that go out to their millions of contributors, and to legislators, and which find their way into newspapers, magazines, television and radio shows.

One anti organization, the Friends of Animals, Inc., headed by its founder, Alice Herrington, is especially virulent on the subject of wildlife management.

In an article titled, "Some Things You Are Not Supposed To Know About Hunters, Hunting and Wildlife Management," Mrs. Herrington has very choice things to say about the Pittman-Robertson program and the 1966 legislation which opened the national Wildlife Refuge System to hunting:

> A direct parallel to these two Congressional moves would be for Congress to support the liquor industry by allocating excise taxes on booze to convert human sanctuaries . . . churches and synagogues . . . into cocktail lounges and bars . . . except on Saturday and Sunday . . . [and to] ensure that the liquor excise taxes be utilized to teach America's young the art of making Bloody Marys in Hail Mary territory just as it has stipulated that some of the weaponry taxes be spent to teach youth the 'safety' of hunting.

The fish and wildlife agencies of this country know Mrs. Herrington only too well. It is her Committee for Humane Legislation that brought suit to block disbursement of Pittman-Robertson funds last year.

In their "Statement of Purpose," the Friends of Animals organization makes this comment: "The kill-for-kicks boys seek to enoble their deeds by claiming to save the animals from starvation. The ploy is undermined by the fact that game animals are created for the most part by self-styled wildlife managers who cut, burn, flood our forests and land with a pattern of ecological horror that upsets nature's balance and eliminates non-game animals."

The Humane Society of the United States indicts wildlife management in a training brochure which says, in part: "The contention that animals are a natural resource is not a scientific doctrine but a biased political assumption."

Real conservationists give thanks that we have developed a system of earmarked funds for wildlife. Can you imagine what would happen if wildlife had to compete with public education and welfare for general treasury funds? There wouldn't be many wildlife funds and there wouldn't be many wildlife. But the anti group which calls itself Defenders of Wildlife, in a magazine article by their official, Michael Frome, says earmarked funds cause "a built-in weakness."

In the same article Mr. Frome quotes Victor Scheffer's book, *A Voice for Wildlife*, as follows: "During its 40 year of existence, professional management has been weakened by inbreeding; in this respect it resembles the professions of education and medicine. The consequences are narrow vision, resistance to change, emphasis on structure at the expense of broad helpfulness and a dwindling sense of humility."

The anti's preach that professional management is just no good, and they are going to try their level best to put the agencies out of business. They'll infiltrate the agencies, they'll get the agencies to compromise, and they'll chip away at them day after day in state after state. The antis have legions of believers and lots of money to pour into the fight against wildlife management. Yes, indeed, wildlife management is under severe political assault.

But, There is a Defense: Ohio Example

There is a defense, and a defense force. The 1977 battle in Ohio over whether to outlaw trapping offers proof and some very good instruction.

In September 1977, two-thirds of the people of Ohio told a scientific public opinion survey that they believed trapping is cruel to animals and they would vote to outlaw trapping in Ohio by amending the state constitution.

But, two months later, two-thirds of the people of Ohio voted *not* to outlaw trapping. After the election, The Wildlife Legislative Fund conducted another scientific public opinion survey to find out why voters changed their mind. People said trapping benefits people. They said trapping is not cruel to animals. Table 1 shows how the pre-campaign attitudes and the actual election results compare by key demographic groups.

Pre-campaign voter attitudes were formed on the basis of one-sided information. The antis had started circulating petitions in early 1976, expecting to be on the ballot that year. The publicity build up began in 1975. So, there was nearly two years of publicity effort before the election campaign—including an estimated $350,000 spent for paid advertising—that preached to people that trapping is cruel and should be outlawed.

The Wildlife Legislative Fund, as a very first step in building the defense, spent the necessary money in late 1976 and early 1977 to determine just how much damage had been done by the antis' early, unchallenged publicity. What, really, did people know and believe, and how deep were their feelings? No matter how intuitive one might be, there is only one valid way to learn how people feel—and that is to scientifically measure their attitudes, using the standard survey and focus group techniques.

This is standard operating procedure whether in a campaign to sell soap, elect a U.S. Senator or build a defense for wildlife management. The wildlife manager accumulates the best scientific data available before making decisions that affect fish and wildlife resources. It's not a guessing game. Building a political defense for wildlife management, or an election campaign to protect wildlife management also is not a guessing game.

Survey Work Was Essential

This early survey work showed the two-thirds majority *for* a trapping ban, but it also revealed other information. Our belief that the great majority of people know little about wildlife or any animals except pets, was clearly affirmed. The contrast in knowledge and attitude between big city people and farmers was dramatic. There also was a marked difference in knowledge and attitude about wildlife between men and women and between people over 35 and under 35. The urban female under 35 years of age was the person who would cast the decisive vote for or against trapping.

Although most people said they were against trapping, they also did not have strong feelings about trapping one way or the other. What people meant was: they were opposed to cruelty to animals—and the only thing they had heard about trapping was that it is cruel. The survey work told us this, and it became a very critical piece of strategic information. In the focus groups we also learned that

Table 1. Ohio referendum to ban trapping, 8 November 1977.

	Pre-campaign voter attitudes	Election results[a]
All voters	66.7% FOR Ban	63.4% AGAINST Ban
Big city voters	73.8% FOR Ban	53.8% AGAINST Ban
Voters under 35	74.5% FOR Ban	58.2% AGAINST Ban
Female voters	77.4% FOR Ban	48.8% AGAINST Ban
Trapping is cruel	63.7% AGREE	58.8% DISAGREE
Actual vote: Yes		1,169,068 36.57%
No		2,027,642 63.43%

[a]All voters and big city voters figures are the actual vote. Big city voters figure is the total vote in the state's eight metropolitan counties. Figures for voters under 35, female voters and trapping is cruel are from the post-election attitude survey conducted for The Wildlife Legislative Fund by Creative Research Services of Cleveland.

when people understand the need to control wildlife populations—and the role of trapping—they will support trapping.

The essence of the findings of this investigative work was this: (1) people are educable about trapping and wildlife management and (2) facts are more persuasive than emotional claptrap.

So the task of the campaign became one of getting people the right information in the right way fast enough and soon enough. In effect, the people of Ohio needed to be force fed a short course on wildlife management. That is a very expensive undertaking. We raised one million dollars. We spent one million dollars. So did the antis. We won the election and the people who raised our money, mainly the sportsmen of Ohio, are the heroes of this election story.

To Sportsmen It Was Survival

The so-called experts looked at the issue and threw up their hands. Can't be won, they said. You'll never be able to beat this cruelty charge, they said. That attitude kept a great deal of money away from us. But the experts did not realize that tens of thousands of people all over the state viewed this fight as a matter of survival. For two years the founders of The Wildlife Legislative Fund, with missionary zeal, had been preaching about the antis' real intentions and the scope of the threat they really pose. The anti-trapping crusade is merely the opening wedge—the tip of the iceberg. The founders preached all over the state, night after night. They preached that the only defense for sportsmen and other wildlife interests was unity and the development of a counterforce—money and professionalism—to fight back.

Ohio sportsmen had no doubt by the summer of 1977 that the Cleveland Amorys, the Brian Davies, the HSUS, the Defenders and the Alice Herringtons have one objective: stop hunting, stop fishing, stop trapping and close down scientific wildlife management practices.

That election was a matter of survival for Ohio sportsmen. The Wildlife Legislative Fund formed them into Ohioans for Wildlife Conservation, with a political committee in each of the 88 counties. Sportsmen pulled in the farmers, organized labor (jobs were at stake), veterinarians, public health officials—all the people who are affected when wildlife populations get out of control. The county committees put up displays at festivals, fairs and shopping centers. They passed out several million pieces of literature . . . and in six weeks they raised over $600,000. They raised it in dimes and dollars at auctions, raffles and bean dinners.

Sportsmen worked because hunting, fishing, trapping and scientific wildlife management practices were on the line. The sooner everybody understands that they are on the line, and really believes this, the sooner we can put the antis out of business everywhere in America.

Trappers and the major sportsman groups across the country also contributed to the campaign. So did the fur industry and the world's largest trap manufacturer, the Woodstream Corporation. The early seed money from these two special interests made it possible to construct the statewide political campaign organization.

When the necessary money was raised it became possible also to construct a winning "education" or media campaign aimed at the urban, 18-35-year-old Ohio female who would decide the vote on November 8. The task narrowed to finding the right messages and the right media mix (best use of TV, radio and print advertising) to get the messages to the targeted voter.

In any selling campaign, the right messages have to do with benefits for people. We wildlife folks are accustomed to talking about benefits for wildlife. What is good or bad for "the resource" is the vernacular. But raccoons and deer and muskrats don't vote. It is the non-wildlife oriented human who votes. So we must couch our arguments in terms that this person will understand—and we must select, from all the messages we could use, those few which are the most compelling. This is not a new concept. Rather, it is Advertising 101—but it has become critical that wildlife professionals understand it, too. I am glad and thankful that the scientist insists upon thorough examination, thorough and properly balanced investigation and evaluation of all aspects and all sides of an issue. That wildlife management is approached this way is why America has abundant wildlife today, why we need professional wildlife managers, why we intend to protect scientific wildlife management practices from the antis' assaults. But, when you are determining the use of a 30-second TV commercial, or the standard 60-second radio spot or a page of newsprint advertising, considerations other than the perfect balance of each separate message take precedent. You have to grab attention in a sea of hundreds of millions of dollars worth of other people's messages . . . or you are drowned out.

Trapping Benefits People

We set out to prove that trapping benefits people and is an essential form of wildlife control. We did it with a mix of media—television, radio, newspaper—and we used the true facts of wildlife and wildlife management as our selling message.

Because television is an emotional medium, we used it for emotional messages. The state public health director talked about the disease problems. The chief of the state wildlife agency talked about the scarcity of habitat, and the need for control. The head of the Ohio Farm Bureau talked about the farmer's problems with wildlife. The mother of a child, the first one of record who had recovered from a diagnosed case of rabies, asked women to vote *no*. Because the wording of the amendment could have outlawed rat and mouse traps too, we got into that subject on TV—and it had a powerful impact in the big cities.

Radio can use longer, more reasoning kinds of messages—and we had lawyers, wildlife biologists, plus the experts we used on TV, discussing various aspects of the amendment and why people should vote *no*.

Newspaper is the most rational and reasoning media, and because of the cost of newspapers compared to free radio and TV, it reaches voters with a generally higher level of education and income. In newspaper ads, we used testimonials from a dozen professionals—wildlife biologists, health officials, national wildlife organizations, the Ohio State Bar Association, the Farm Bureau, the AFL-CIO and others—nailing down the facts of the appeal that trapping benefits people and is necessary to wildlife control. We market tested the ads and we kept polling.

The media campaign began the third week in October—three weeks in advance of the election. Within 10 days a poll told us that we were effecting a significant turnaround. Another poll, taken a few days before election day, told us that the election was a dead heat—50 percent would vote yes, 50 percent would vote no. And, of course, as noted before, the final election day result was a resounding defeat for the amendment—63.4 percent of all voters voted no. As the facts about wildlife management became known, there was a steady, dramatic, irreversible shift in voter attitudes—away from the antis and toward reason and good sense.

The trapping fight was considered the most spectacular upset in Ohio election history. The Ohio Associated Press rated the trapping controversy as one of the three biggest stories of the year.

Media Will Support Wildlife Management

The decisive factor with the urban voter was the advertising campaign, but there were other information programs at work, too. We did a significant press program, including weekly news conferences all over the state. We personally talked to the editor or publisher of Ohio's 12 major metro dailies and to the heads of the major radio and TV stations that take editorial positions on election issues.

Eleven of the 12 big newspapers editorially urged their readers to vote against the trapping ban. All the radio and TV stations that take positions did the same. We know of only two newspapers in the state, including the weeklies and special interest papers, that took the antis' side. There is a message here for sportsmen and wildlife people all over America: the media of this country is *not* anti-sportsman or anti-wildlife management. The problem simply is that the media gets lots of material from the antis and almost nothing from us. We can get off the outdoors page when we have something to say.

Another major component of the campaign to reach the urban voter was our "community relations" program, which is a fancy name for the process of getting endorsements. We got hundreds including the state bar association, state veterinary association, state AFL-CIO, parent-teacher associations, church groups, civic improvement associations, of course all the farmer groups, soil conservation groups—even some of the county executive committees of the Republican and Democratic Parties.

It all adds up to this: wildlife management is a very salable commodity when you talk in terms of benefits for people. We can beat the antis, and that is really why I was anxious to develop this paper for the 44th North American Wildlife and Natural Resources Conference in Toronto in March, 1979.

Defense Force: The Wildlife Legislative Fund of America

The organization I represent is the Wildlife Legislative Fund of America (WLFA). We have a companion organization called The Wildlife Conservation Fund of America (WCFA). We are an out-growth of the Ohio organization that beat the antis so handily in 1977. In 1978, we were invited to California to help create a defense against another of the antis' ballot issues. We work all over the country when sportsman or wildlife management groups ask for help. Right now we're assisting in New Jersey, Georgia, and North Carolina. Illinois is calling. California is calling again.

The distinction between our two organizations is that the Conservation Fund handles research, information-education and legal defense, and the Legislative Fund is the political arm, the twin that gets involved in legislative battles and ballot campaigns. The staff and board members of each organization are the same people. Contributions to the WCFA are tax deductible to the donor. Foundations and corporations may make grants to the WCFA with IRS sanction.

Our board consists of 12 nationally prominent sportsman-conservationists and wildlife management experts. G. Ray Arnett of California is chairman. He is the immediate past president of the National Wildlife Federation and a former director of the California Fish and Game Department. A founder of the Ohio Wildlife Legislative Fund, James H. Glass, is president of the national groups. Daniel M. Galbreath, who owns the Pittsburgh Pirates and Kentucky Derby race horses, is treasurer. Wildlife management experts on the Board include Dale L. Haney, former head of the Ohio Division of Wildlife, Joseph W. Hudson, former chairman of the South Carolina Wildlife and Marine Resources Commission and Edward L. Kozicky of the Winchester Group's Conservation Department, who is respected by wildlife managers everywhere. We also have political experts such as Abe Feinglass, international vice-president of the AFL-CIO, Thomas E. Bass of Colt Industries and General Joseph J. Foss, former governor of South Dakota. Lee C. Howley, S. Preston Williams and Herman Taylor, Jr. complete the roster. Besides being attorneys or businessmen, these men also have had the distinction of being national president of Ducks Unlimited at one time.

We have a single purpose: to protect the heritage of the American sportsman to hunt, to trap and to fish . . . and to protect scientific wildlife management practices. The protection we offer is political, legislative, public relations, legal and management help to fight the antis anywhere in the United States—in the media, in the courts, in the legislative halls and in issue election campaigns.

At this point in the sportsman's and wildlife manager's struggle with the antis, we are a defense force. Ultimately, we shall have to take the offensive. It is the minds of today's children that count. The real story of wildlife management must be told to them so we can counter the antis' dedicated program to raise a generation of Americans who will oppose wildlife management.

What is the Defense?

If the WLFA-WCFA is a defense force, what is the defense? What have we learned from battling the antis in Ohio and in the other states that will instruct sportsmen and wildlife managers all over America?

First, be convinced that the antis intend to stop hunting, stop fishing, stop trapping and close down wildlife management. This *is* a struggle for survival. There is no compromise. They will not be deterred. Compromise to them is a tactic. To us it means simply going under slowly, but going under just the same.

Second, appreciate that all fish and wildlife interests—and all interests that are affected by the various other programs of the antis, for example their opposition to modern farming methods—must come together for the single defense purpose. Appreciate that this can happen—has happened. For example, it is now the national policy of the AFL-CIO to oppose anti-trapping campaigns everywhere in America because so many jobs are at stake.

Third, be convinced that the facts are on our side and do not be intimidated by the antis' shrill outbursts. Believe that the American people and the American press are educable about the necessity for wildlife management. They will understand, if we tell them, that uncontrolled wildlife populations are bad for people and bad for wildlife. Pledge to talk to laymen in terms of benefits for people. Remember that raccoons don't have many votes. Most don't even register.

Fourth, don't dignify the antis' arguments. Don't debate whether trapping is cruel. Talk about how trapping is necessary for people. People then will conclude that it is not cruel. The cruelty issue is a no-win issue. It's another "when did you stop beating your wife" tactic. The antis know it. That is why they use it.

Don't spend much more money and time trying to prove that few or no non-target animals get caught in leghold traps. This is another one of their irrelevant arguments.

The three-legged dog phenomenon is a hoax. Don't believe for a moment that all they want to do is outlaw just the leghold trap. Look at the language of their ballot issues. Look at the language of their legislation. They want to stop trapping. Period. They use the leghold simply as a strategy.

The "do not dignify the anti arguments" approach should be used as you confront any and all anti efforts. Does anyone really think that all Alice Herrington wants is to assure that Pittman-Robertson projects get a proper environmental evaluation? If she has her way, the state agencies will never again get one dime of Pittman-Robertson money to spend. The point is this: stick to the wildlife management facts. Don't help the antis sell their baloney, which is what we do every time we engage in their debate, and don't be afraid to call their baloney, baloney.

There is no Compromise

The wildlife manager does have to listen to all segments of society, but he has to recognize that he cannot compromise with the anti organizations. The antis never lose sight of their objective, which is to stop the taking of fish and wildlife anywhere, anytime—and, not so incidentally, to continue to collect millions in contributions. The wildlife manager is in their way. To many of the antis, fraud perpetrated for the glory of the cause is not fraud—it is an acceptable strategy.

The wildlife professional is trained to analyze all sides of a question, so his tendency is to try to see the anti point of view as well as his own. The antis chip away at wildlife management, a little here, a little there, and one of these days they could have the agencies out of business.

Defending is a task that requires specialists. Wildlife managers are specialists in their field. They know the facts. They have the evidence. We have seen the need for the development of a different kind of specialist organization—one that can combine the wildlife manager's specialized and factual knowledge with the skills in litigation, lobbying and public information needed to challenge and beat the anti organizations.

Because of professional managers' status as government employees, it probably is not in the cards for them to create a loud defense when the antis attack them and their profession—in a court case, or in a legislative drive. But a third party can—a third party representing the sportsmen of this country, the farmers, the water experts, the foresters, the furriers, the labor organizations, and the wildlife managers.

If any wildlife manager in America has a fight on his hands, we are the third party that can help him win it. That's the only reason we exist. Call us anytime.

Coordinating Wildlife Habitat Inventories and Evaluations

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Opening Remarks

Charles T. Cushwa

Why are we concerned about coordinating wildlife habitat inventories? There are several reasons:

- Overlapping data collection is expensive.
- We are making environmental assessments that are inadequate.
- We experience delays and endless controversy in major federal projects.
- Poor coordination between state and federal agencies.
- Unnecessary environmental damage.
- Poor public image of the role of science in solving environmental problems, that we do not have our act together.[1]

The objectives of this special session are:

1. Recommend a course of action to assure a sustained yield of fish and wildlife habitat to maintain healthy ecosystems and to meet future demands for the fish and wildlife resource.
2. To determine the adequacy of information available about fish and wildlife habitat to meet the needs of state and federal wildlife managers at different decision-making levels.
3. To review the current status of wildlife habitat inventories being conducted by federal and state agencies and recommend action to improve our current inventory of fish and wildlife habitat.
   - What is being done?
   - Why is it being done (objective)?
   - How is it being done (methods)?
   - Identify opportunities for coordination.

[1]Some of this information was taken from a memo of 1/3/79 from John Buffington, Council on Environmental Quality, to the Environmental Data and Monitoring Task Force Executive Committee.

Background

There is a finite supply of fish and wildlife habitat available in North America. Theoretically, we should be able to take a picture of it, classify it, and inventory it. Generally, we can stratify the habitat of fish and wildlife in North America into four major land and associated water uses, including urban land, agriculture land, forest land, and rangeland. In addition, we can further stratify each of these broad land uses into major ownerships—federal government, state and provincial governments, and private individuals. Decisions which influence fish and wildlife habitat on all of the lands are made at different levels including the international, national, regional, state, substate, and site levels. We propose to review the land and water base including major land uses and land ownerships at different decision-making levels to determine what is being done today to inventory fish and wildlife habitat; what are the legal requirements to make inventories of wildlife habitat; what are the needs of wildlife managers at different decision making levels for information generated by wildlife habitat inventories; and what can be done to improve our efforts to obtain this information.

Managers' needs can be broadly summarized into six questions which apply to each decision-making level:

1. What animals occur in a geographic area (the world, North America, a state, county, ecosystem, stand or site)?
2. What are the habitat requirements of these animals?
3. How much of the required habitat is available?
4. Where is the available habitat located?
5. How does the available habitat respond to alternative land uses and management practices?
6. What activities are required to insure that habitat requirements of fish and wildlife are provided for in development plans and actions?

Without answers to these questions it is difficult to describe the resources, determine their value, or determine how the resources will respond to alternative land uses or management practices. This information is also required to coordinate fish and wildlife research and management programs.

Special Concerns About Coordination

A fish and wildlife assessment is being made by the Forest Service for 1980 on all forest and rangelands in the United States. It is designed to provide a broad picture of the fish and wildlife situation including supply, demand, and opportunities to enhance fish and wildlife resources on all 1.6 billion acres (0.65 billion ha) of forest and rangeland in the United States. The assessment is not designed to replace on-the-ground management or to fill the site-specific inventory needs. Conversely, the intensive site-specific inventories were not designed to meet the needs of the Forest and Rangelands Renewable Resources Planning Act (RPA) Assessment on all forest and rangeland in the nation. We will hear in this session that a lot of people are involved in inventorying and evaluating fish and wildlife habitat. To date many of these efforts have not been coordinated or evaluated. We should be able to summarize and display the information at different decision-making levels, from the 5-acre wetland in New York (lower level) to the national level (upper level). For example, the RPA fish and wildlife assessment will influence major programs on federal lands such as those managed by the Bureau of Land Management, Forest Service, Fish and Wildlife Service, Defense Department, etc. This assessment will also influence federal–state cost-sharing programs on state and private lands by establishing priorities which reflect demand, supply, and opportunities for enhancing the fish and wildlife resource.

The Soil Conservation Service is charged by the recent "Resource Conservation Act" to make an assessment of resources on agricultural lands of the nation. The Fish and Wildlife Service is making an inventory of all wetlands in the nation. There is also considerable concern about coastal zones, riparian habitats, and relationships among livestock and fish and wildlife habitats. Inventories and assessments are underway in each of these areas. In all this flurry of individual activities, how can a common base of information on fish and wildlife resources be established? How cost-effective are our efforts? Are our efforts adequate to meet present and future needs to improve management?

Today, we plan to review part of the situation as it is in 1979 and chart a course for our future. We are pleased that you are here to help us with this important task.

Trends and Needs in Federal Inventories of Wildlife Habitat

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Introduction

Habitat inventories, long a basic tool of wildlife and fisheries management, are assuming increasing importance as the result of two major developments affecting federal resource management programs.[1]

The environmental movement of the late 1960s and early 1970s led to federal legislation, regulations, and executive orders requiring increased attention to the environmental consequences of federal actions, including those resulting from management of natural resources. Such legislation as the National Environmental Policy Act of 1969, with its requirements for environmental assessments and impact statements, generated new needs for information on fish and wildlife resources and habitats. Other examples are the Endangered Species Act of 1973, with its requirements relating to critical habitat determination, and the Clean Water Act of 1977, with its provisions relating to wetlands protection.

A slightly more recent trend has been federal legislation emphasizing renewable natural resource appraisals to guide national policies and programs, as well as accelerated planning for management of Federal lands. In 1974, the Congress enacted the Forest and Rangeland Renewable Resources Planning Act. This legislation authorizes the Forest Service (FS) to conduct periodic assessments of the renewable resources on all of the nation's forest and rangelands to identify management needs, opportunities, and programs.

The National Forest Management Act of 1976 requires that interim land and resource management planning be completed on all National Forests by 1985, thus generating another major need for habitat information. The Federal Land Policy and Management Act of 1976 requires the Bureau of Land Management (BLM) to develop multiple use management plans for lands under its administration, and to inventory the resource values of the public lands in order to identify changes and

[1]Although this discussion focuses principally on wildlife habitat inventories, inventories of fisheries habitat also are an integral part of many of the programs discussed. The specific technical problems between fisheries and wildlife habitat inventories differ, but the same general issues apply.

emerging resource needs. Under the provisions of the Soil and Water Resources Conservation Act of 1977, the Soil Conservation Service (SCS) is conducting periodic appraisals of the soil, water, and related resources of the nation, including data on the quality and quantity of fish and wildlife habitats. The purpose of this appraisal is to assure that the Department of Agriculture's programs for the conservation of soil, water, and related resources address long-term needs.

The effect of these developments has been to stimulate a major need for fish and wildlife habitat information, and to provide opportunities and financial resources for gathering such information on a larger scale than ever before. The effectiveness with which this information is collected, aggregated, and analyzed will be critically important for the future of fish and wildlife resources. Because the land base on which they depend is finite, these resources have been, and increasingly will be, competing with other values such as urban and industrial development, crop production, timber harvest, water resource and energy development, and livestock grazing. National policies and program decisions on these competing values and uses will be influenced by an increasingly comprehensive information base concerning opportunities, needs, and benefits of commodity production. If a comparable information base does not exist for wildlife, wildlife resources are unlikely to receive the consideration they merit. Provision of that information base presents a major challenge to all concerned with the nation's wildlife.

This paper was developed by representatives of four agencies participating in a Federal coordination effort under an Interagency Agreement Related to Classifications and Inventories of Natural Resources. The paper, as well as the entire morning's session, reflects a growing concern that state and federal wildlife habitat inventories need to be better focused and coordinated to meet future needs.[2]

The objectives of the paper are to provide an overview of major Federal wildlife inventory activities, to describe the conceptual issues that must be addressed in assuring that wildlife inventory information will be adequate to meet management needs, and to discuss needs and problems related to federal and state-federal coordination.

Overview of Current Federal Wildlife Inventories

This review focuses on the four federal agencies most active in the conduct of wildlife habitat and related surveys: BLM, FS, SCS, and Fish and Wildlife Service (FWS). Many other agencies, such as the National Park Service, Heritage Conservation and Recreation Service, Tennessee Valley Authority, and Department of Defense agencies also conduct or sponsor wildlife surveys on a lesser scale. In addition, other natural resources inventories, while not directly related to wildlife, can provide important supplementary information. For example, the Geological Survey's Land Use and Land Cover mapping program (Anderson et al. 1976) provides broad-based information which, while not directly wildlife-related, can assist in interpreting wildlife habitat information.

[2]The states, recognizing the impact on their programs of uncoordinated federal inventories and requests for wildlife information, have played an important role in stimulating coordination at the federal level. For example, the Public Lands Committee of the Western Association of Fish and Wildlife Agencies has made a number of suggestions concerning this.

Bureau of Land Management, U.S. Department of the Interior

BLM manages more than 170 million acres (68.9 million ha) of public lands in the 11 western states, with additional lands located in Alaska. The Bureau also administers mineral leasing on federal lands, on private lands overlaying federally owned mineral deposits, and on the nation's Outer Continental Shelf. Collection of wildlife habitat information to assist in the management of western range and forest lands managed by BLM has long been a part of the agency's program. Recently, however, BLM has broadened the scope of its wildlife inventories.

The Federal Land Policy and Management Act (FLPMA) of 1976 specifically directs BLM to " . . . prepare and maintain on a continuing basis an inventory of all public lands and their resource and other values . . . ", further stating that "This inventory shall be kept current so as to reflect changes in conditions and to identify new and emerging resource and other values." BLM has a clear and specific obligation to inventory wildlife habitats on lands it administers, because FLPMA defines fish and wildlife development and utilization as one of the six major uses on public lands.

In fiscal year 1979, some 20 million acres (8.1 million ha) of western rangelands are scheduled for resource inventories. It is anticipated that in the contiguous 11 western states inventories will be updated every 10 to 15 years. The Bureau is developing management plans and decisions from a broad data base which includes a variety of natural resource inventories. The range of resource inventories being conducted includes cultural resources, soil, vegetation, water, and wildlife. These inventories, in conjunction with economic and social information, collectively provide a basis for developing and implementing sound land use plans.

Wildlife habitats on BLM-administered lands are mapped and measured in terms of homogeneous units of existing vegetation and special habitat features such as caves, cliffs, and seeps. Key wildlife areas, such as seasonal big game ranges or raptor nesting concentrations, are defined in terms of plant community sets, special geological structures, or a combination of both. Emphasis is being given to identifying areas used by endangered species to delineate critical habitats. Plant communities, both individually and in groups, are the functional focal point for assessing the impacts of livestock grazing and other activities on wildlife populations because most land management activities directly affect vegetation.

BLM is moving towards a standardized and multiple purpose soil and vegetation inventory within which most wildlife habitat components are to be incorporated. This inventory is termed the Soil-Vegetation Inventory Methods (BLM 1978a). It is planned to use this approach on all western rangelands managed by the Bureau, and the method is being modified to include woodland and forest ecosystems. Field teams consisting of resource specialists (i.e., soils, plants, wildlife) identify and map present and potential homogeneous units of soil and vegetation. A variety of vegetative characteristics are measured, including species composition, strata height, biomass, and horizontal and vertical cover. These data are intended to provide the basis for evaluating the present and potential production of forage, water, wildlife, and other resources on a site-specific basis. However, as it becomes available, the site-specific information can also be aggregated and used in regional and national assessments.

Forest Service, U.S. Department of Agriculture

As in the case of BLM, the FS has conducted wildlife habitat inventories as a partial basis for meeting its land management responsibilities for many years. However, until the last decade, all of these inventories were designed to meet only the needs of individual National Forests. Most of the commonalities that existed resulted from agency requirements for budgeting and reporting, from the interests of the many cooperating state wildlife and fish agencies that happened to be consistent across the nation, and from the personal–professional interactions among agency staff and line officers and with cooperators.

This situation has changed markedly, beginning with passage of the National Environmental Policy Act of 1969. This law's requirements for environmental impact evaluations set into motion more-or-less comparable information-gathering efforts. The subsequent Forest and Rangelands Renewable Resources Planning Act of 1974 accelerated this trend by requiring periodic national assessments of all renewable resources, including wildlife, on the Nation's 1.6 billion acres (0.65 billion ha) of forest and rangelands. The Act also required development of information bases that could answer specific national and regional questions regarding wildlife and other resources (Schweitzer et al. 1978). Finally, the National Forest Management Act of 1976 and subsequent implementing regulations have provided rather rigorous guidelines for land and resource management planning. In combination, these and other laws such as the Endangered Species Act have required wildlife inventory data from across the nation that are comprehensive and mutually compatible both for planning and analysis and for on-the-ground management. FS is in the process of developing wildlife inventory information directed towards these requirements.

The most comprehensive wildlife inventory data base compiled by FS is that supporting the 1979 National Assessment of wildlife and other resources. Its present status will be discussed in the panel following this session by Hoekstra et al. (1979). Essentially, broad relationships of fish and wildlife to their habitats are estimated by: (1) stratifying the nation's land and water base into relatively homogeneous areas, defined by existing forest types and potential range vegetation types or ecosystems; (2) identifying all resident and common migrant fish and wildlife species associated with each ecosystem within each state; and (3) using information from timber and range inventories to provide rough estimates of the extent of habitats, where possible, and using qualitative descriptions of habitats where necessary.

The 1979 Assessment, based upon existing information, will provide only a rough approximation of the extent and status of wildlife habitats. However, the opportunity exists to gather new information for the 1989 report. Particular attention is being paid to ensuring that such information will support evaluations of opportunities for managing wildlife habitat while explicitly considering other, sometimes competing, uses of the same land areas.

Soil Conservation Service, U.S. Department of Agriculture

Wildlife habitat inventories conducted by SCS have been those done in connection with its planning and operational activities, such as implementation of the

Watershed Protection Act of 1954 and provision of technical assistance to Conservation Districts and individual farmers. As in the case of the federal land management agencies, such surveys were designed on an individual basis to meet local or site-specific needs. The surveys were often subjective in nature, and little, if any, attention was given to the need for standard approaches.

The Soil and Water Resources Conservation Act of 1977 (RCA), however, provided the opportunity and requirement for SCS to conduct broad appraisals of wildlife habitat. The purpose of the RCA is to ensure that the Department of Agriculture's programs for the conservation of soil, water, and related resources respond to the nation's long-term needs. The Act requires periodic appraisals of the status and condition of those resources. The appraisals are to cover all nonfederal lands and assess the status, condition, and trends of soil, water, and related resources. The following types of lands are being addressed: prime and unique farmlands, flood prone areas, mined land, cropland, pastureland, rangeland, forestland, wetlands, riparian vegetation, and small water bodies. All data are cross-linked to soils to support interpretations for resource use and development.

The 1979 national appraisal is currently approaching completion. This first appraisal is based entirely on available data. A large part of the information is coming from such sources as SCS's 1977 Natural Resources Inventory, the 1975 Potential Cropland Study, and the Census of Agriculture.

No wildlife habitat inventory information is included; however, estimates of the potential impact on wildlife habitat of status and trends in land use conditions will be included in the 1979 appraisal. This information is being developed as follows: the appraisal will include statistical estimates, from the previously mentioned sources, on such practices and problems as loss of croplands to urbanization, the rate of conversion to larger farms with less vegetative diversity, the amount of crop residue left in fields, the amount of strip cropping, the extent of erosion, and many others. Since the impacts of these practices are generally understood, and can be related to wildlife habitat condition, a general assessment can be made of overall trends and problems in the agricultural arena as they relate to wildlife habitat. This information will be tabulated by states.

An Applied Conservation Effects System is being developed. This system will monitor conditions that influence wildlife habitat quantity and quality: changes in cover types and conditions, erosion, water use, and the extent of reduced tillage on a year-to-year basis. This information is to be part of the continuing evaluation and analysis system of RCA.

The next RCA appraisal, to be completed in 1985, provides the first major opportunity for SCS to participate in the systematic collection of new wildlife habitat information. A basic source of information for the appraisal will be a stratified random sampling procedure developed for SCS's Natural Resources Inventory, in which carefully selected plots, usually of 160 acres (64.8 ha) in size, are plotted on aerial photographs and evaluated. In the survey used for the 1979 appraisal, on-site observations were made at 210,000 points, including, but not limited to, such factors as soil, slope, erosion, and agricultural management capability.

This sampling method, along with others being considered, affords the opportunity to collect additional information, specifically on wildlife habitat. SCS biologists currently participating in planning for the 1985 appraisal are working to identify wildlife habitat parameters that should be included. Thus there is a real opportunity to incorporate wildlife habitat features and measurements which will not only contribute to RCA objectives, but also be compatible with other wildlife data collection efforts.

Fish and Wildlife Service, U.S. Department of the Interior

As the principal federal wildlife agency, FWS conducts surveys of wildlife habitat under a variety of authorizations. These include migratory bird legislation under which FWS conducts habitat surveys to guide its land acquisition activities. Site-specific habitat surveys are also conducted on the over 34 million acres (13.8 million ha) of refuges and waterfowl management districts in the National Wildlife Refuge System to support development of management plans. The Endangered Species Program conducts investigations to identify habitat critical to the survival of endangered species. Results are used to assist federal agencies in protecting critical habitat as provided for in Section 7 of the Endangered Species Act of 1973. Under the Fish and Wildlife Coordination Act, various habitat surveys and studies on a local or regional scale are conducted to support the formulation of FWS recommendations for mitigating the impacts of proposed water and related land resources projects.

Unlike the other three agencies previously described, FWS is not operating under recent organic national planning legislation specifically mandating preparation of national inventories, appraisals, or assessments. However, FWS is developing broader regional and national habitat surveys, under its various legislative mandates, such as the Fish and Wildlife Act of 1956, which authorizes investigations for the purpose of making periodic reports on " . . . the availability and abundance and the biological requirements of the fish and wildlife resources."

The broadest wildlife habitat inventory currently underway within FWS is the National Wetlands Inventory (Montanari and Wilen 1977), which will update the last nationwide survey of wetlands completed in 1954. The inventory will develop maps on 1:24,000, 1:62,000, and 1:100,000 scale. These maps will be prepared from high level aerial photography and will cover many of the nation's prime wetlands regions such as coastal areas, the Mississippi Delta, and the prairie potholes. In many cases, it will be feasible to identify wetlands of less than a fraction of an acre in size. The inventory will include a computerized data base of wetlands statistics developed from those maps.

National Wetland Inventory maps will provide an important tool for use in wetland protection programs, such as wetlands acquisition, regulatory activities under Section 404 of the Clean Water Act of 1977, and state coastal zone management. In addition, the inventory will include a National Wetlands Status Report, providing an analysis of the status and trends of the nation's wetlands between the early 1950s and the 1970s, based primarily on a statistical sampling program. This information will serve to document wetland losses and identify priorities for protection efforts.

In accordance with requirements of the Clean Water Act of 1977, the inventory is scheduled for completion in December 1981. Continuous revision, refinement, and updating subsequent to that date is planned in order to maintain a real time information base on wetlands.

In addition to the National Wetlands Inventory, FWS is conducting broad regional inventories of other habitat types such as major coastal ecosystems (for example, Maine coast, Oregon-Washington coast) and terrestrial ecosystems in the coal-bearing areas of the western United States. These regional inventories reflect FWS efforts to develop a strengthened information base on wildlife resources for use in environmental assessment and related purposes.

Wildlife Habitat Inventory Concepts and Issues

Adequacy of information on wildlife habitat will be an increasingly important issue for environmental and natural resources management in the decade ahead. If wildlife is to receive equal consideration with other competing values, the information must be adequate to display the trade-offs, gains, and losses involved in various management options. For example, the information should permit accurate analysis of the interactions between national timber production efforts and maintenance of habitat for forest wildlife.

Inventory programs must be coordinated to assure maximum efficiency and utility of the information collected, particularly in a time of decreasing public budgets. Funding resources available for conducting wildlife inventories will prove most adequate to meet the need if they are meshed to provide a joint attack by the various agencies concerned. In addition, and even more important, wildlife habitat data will be useful only if obtained within a conceptually sound framework.

A number of important conceptual issues still must be resolved if wildlife inventories conducted during the 1980s are to be an adequate basis for establishing wildlife-related policies. These interrelated issues involve all aspects of the inventory process and are as follows: identification of information needs, development of classification systems, selection of inventory methods, selection of analytical methods, and information management.

Information Needs

Fundamental to design of any data collection program is a recognition that a clear identification of information needs should provide the basic underpinning. This involves defining the questions to be answered and identifying the data needed to answer those questions. This, in turn, determines the scale and level of detail required, the types of inventory methods that can be utilized, and the costs and feasibility of providing the information. Practical budgetary limits tell us that we cannot afford to develop data that are more precise than those required to meet user needs.

As already indicated, information requirements stemming from legislative developments of the last decade have caused many federal inventory activities to move rapidly from studies designed by managers to meet their own individual information needs towards a broader, more structured approach through which information can be aggregated to address broader needs. Wetlands information needed to establish the status and trends of wetland resources regionally or nationally is quite different from that required to assess the impact of a specific dredging project to be reviewed under the Fish and Wildlife Coordination Act. The wildlife-related information needed for FS RPA National Assessment purposes is of lesser resolution than that required for on-the-ground management purposes within a single National Forest or District. Regional assessments conducted to determine whether to locate energy facilities in one area or another require different information than studies conducted for detailed site location and for impact mitigation within that site.

In striving for consistency in future Federal inventory efforts, we must recognize that user needs will vary widely, both within and among agencies. A responsive inventory program must be designed to meet the needs of various and diverse users. An inventory program designed to support national appraisals or broad resource planning activities cannot provide all the detailed information required to meet all individual site-specific needs; the costs would be too great. However, if properly structured, the information collected can provide a meaningful framework or context, through which individual site-specific needs can be better understood. Conversely, standardization of site-specific appraisals and design of a statistically sound program of detailed site surveys would allow for aggregation of information to also contribute significantly to national or regional appraisals. Further, if the standards by which the data are collected are comparable, data collected to meet the special information needs of one agency can also contribute to the needs of others.

Since a variety of user needs must be met, the solution is to design systems through which collection of data at different levels of detail can be structured hierarchically. Fortunately, many common information elements can be defined that are necessary to answer questions relating to wildlife habitat relationships regardless of the level of detail of a particular inventory. However, many unresolved technical questions remain concerning how to mesh "top down" inventories, designed on a widescale basis, with the "bottom up" information gathered in highly detailed surveys of individual land units. This is an area which requires increased attention.

In addition, much remains to be done to clearly define the full range of wildlife information needs associated with national inventories and appraisals. Individual agencies have been working to identify their needs. For example, BLM has identified its information needs for land records and resource inventories, including wildlife resources. The process required almost 2 years and will be expanded to cover a broad range of other topics, including economic and social data needed in land-use planning. User needs for land records and resource inventories were translated into parameters or data elements, which were then defined by individual programs (i.e., watershed, wildlife, range). For those data elements used by more than one program, a common definition was developed where possible. To the greatest extent possible, data elements commonly used by other agencies were incorporated into BLM's Data Elements Dictionary.

A FS-wide study to define legal, administrative, and management requirements for wildlife data and current availability of those data has been proposed as a means of defining areas needing further work. Attention would be focused on types and level of data, and by ownership category for all wildlife species. The results would serve as guides to setting priorities for future FS inventories.

Despite efforts such as these, it is probably accurate to say that an adequate definition of wildlife information needs still remains to be accomplished as a basis for designing the national inventory programs of the next decade.

Classification Systems

Effective habitat classification systems are an essential part of the inventory effort because, through identifying geographic areas and ecosystems with similar properties, they provide the necessary structure for designing cost-effective stratified sampling programs and permit aggregating the information acquired so that a variety of questions can be answered. Because similar ecological units can be expected to respond in a like manner to similar management practices or environmental stresses, classification systems increase our capability to generalize, to extrapolate research results, and to transfer management experience. To date there is no generally accepted classification system guiding the wildlife inventories of the Federal agencies. The development of standard or compatible classification systems to be used in inventorying all renewable natural resources is a critical problem in organizing future coordinated efforts.[3]

In the past, FS developed a number of classification systems for different, largely functional, uses. In cooperation with other agencies, it is now trying to formulate a single National Land Classification System to use in conducting the 1989 national assessment (Driscoll et al. 1978). The proposed system is based upon four relatively independent components—potential vegetation, soil, land form, water—organized into hierarchical classifications. A recent interagency review suggested major revisions in the land form and water components and noted the need for further work in relating the system to mapping procedures, sampling techniques, and component integration.

Currently, BLM aggregates wildlife data according to its Integrated Habitat Inventory and Classification System (BLM 1978b). This classification provides a six-level hierarchical system for organizing species occurrence data from the smallest geographic units (special features and plant communities) to the largest units (physiographic regions). At the higher classification levels, data can be crossed into other classifications, including Kuchler's (1964) associations and Bailey's (1978) ecoregions. Since the lowest level at which inventory data are collected is the present and potential plant community, these data also can be used in component classifications including the proposed National Land Classification System. BLM is developing a classification system for aquatic wildlife habitats, with consideration being given to the FWS wetland/aquatic classification (Cowardin et al. 1977).

The SCS is basing its RCA assessment on a classification which is organized around relationships significant to natural resource use and will be displayed on a state and farm production region basis. This approach will group the organizational geographic units related to land use, topography, climate, water, and soil into Land Resource Regions and Major Land Resource Areas (Austin 1972). The data collected are statistically reliable at state level aggregation.

FWS has developed a classification system for wetlands and associated aquatic

[3]For a comprehensive discussion of current problems associated with development of classification systems, see the special issue on classification of the Journal of Forestry (October 1978), and the Proceedings, National Symposium on Classification, Inventory, and Analysis of Fish and Wildlife Habitat (U.S. Fish and Wildlife Service 1978).

habitats, which is being used to conduct the National Wetlands Inventory. This system is expected to replace the system developed by Martin et al. (1953) which was used in the 1954 inventory as reported in Shaw and Fredine (1956), which has come to be widely utilized for wetlands management since its publication. FWS has also been developing improved approaches to wildlife habitat classification for habitats other than wetlands, and is working closely with the other three agencies concerned attempting to develop compatible systems.

In summary, although each of the four federal agencies concerned has special information needs and separate classification systems developed to meet those needs, they are currently working together to attempt to develop commoon or compatible systems. This interagency cooperation is intended to stimulate the development of a truly multi-purpose classification system for multi-agency use in inventory programs.

Inventory Methods

Inventory methods vary widely from on-the-ground surveys to use of aerial photography and satellite imagery. Current developments in remote sensing are revolutionizing techniques for conducting wildlife inventories by dramatically upgrading capability to assemble reliable information on wildlife habitat types over vast land areas. However, many features important to wildlife still require on-the-ground observations.

Strategies for conducting wildlife habitat inventories vary widely. For example, for the FWS National Wetlands Inventory high altitude aerial photography is the standard method employed. In Alaska, LANDSAT imagery is being used because the enormous land area to be covered would make the use of aerial photographs economically prohibitive. Ground surveys are done principally to validate the results of photo interpretation or to provide information on special features. BLM, on the other hand, uses aerial photography to pre-type land units as a starting point for its standard Soil–Vegetation Inventory Methods which are based principally on detailed, on-the-ground surveys.

Key factors in selecting inventory methods are the nature of information and level of detail required, the size of the area to be covered, and time, cost, and personnel constraints. For example, FWS and BLM are currently working jointly to structure the program of wildlife inventories that will be required in connection with the U.S. Department of the Interior's coal leasing program. Basically, two levels of detail are being considered. The first level would be designed to support formulation of management framework plans for broad areas. Information would be collected on the general wildlife situation through analyses of existing information and broad habitat/population survey data. These inventories would require data with a resolution of between 5 to 40 acres (2 to 16 ha), depending on habitat variability, and would be used, in part, to identify large areas unsuitable for surface coal mining. The second level of survey would develop information with resolution between 0.5 and 5.0 acres (0.2 to 2 ha), and would support detailed management decisions such as stipulations on coal mine operation and identification of small areas unsuitable for coal development. Both levels will have a common underpinning of habitat units, but will involve different inventory approaches, different per acre costs, and different results in terms of information provided.

The fact that widely different approaches to inventories are necessary emphasizes the importance of establishing comparability standards and of finding ways of meshing "top-down" and "bottom-up" inventories. A highly desirable goal would be establishment of a standard hierarchy of inventory procedures, ranging from the national to the site-specific.

An additional problem is posed by the fact that increasingly, FS, BLM, and SCS are expected to conduct their wildlife habitat inventories as part of multiple-resource inventory activities. Two basic factors contribute to the trend towards multiple-resource inventories. First, trade-offs and interactions among resources produced from a finite land and water base cannot be examined by looking at the various resources as isolated entities; and second, given the increasing amounts of information required for all resources, multiple-resource inventories are more efficient than parallel, but separate, functional efforts.

In those instances where it is impossible or inefficient to gather all information at one time, it is still essential at least to have common geographic locators for inventories of all resources. The trend towards multiple-resource inventories adds to the importance of clearly identifying the wildlife parameters that must be included, if realistic interpretations of habitat values are to be made. In the current national appraisals by SCS and FS, existing inventory data related to timber, forage, and water resources are being used as surrogate measures of wildlife habitat to make projections concerning future conditions. This has been necessary because no quantitative inventory of wildlife habitats exists for any significant part of the nation's land base. For the future, it will be important to test the validity of these surrogates and to identify more meaningful characteristics of wildlife habitat for inclusion in multiple-resource inventories.

Research on techniques for expanding traditional forest inventories to acquire additional data that are specific to wildlife habitat is reflected in FS's recently completed inventory of all forest lands in South Carolina. This effort focused on expanding the existing timber inventory into a multi-resource inventory (McClure et al. 1979).

Additional data taken at each sample location included some of the information needed to estimate the extent of wildlife habitat, recreation use, range suitability, water quality, erosion hazards related to forestry practices, and the interactions among resources associated with the forest conditions found in South Carolina. A major goal of the pilot study was to quantify and describe all the vegetation at each sample location in relation to the observed uses of the forest land. It was found that many of the data elements already being collected in the regular timber inventory were also useful in assessing non-timber resources. However, additional data elements specifically required for evaluating wildlife habitat attributes were included (for example, wildlife plant foods, nesting, and cover features). While evaluations of the inventory data have not yet been completed, it appears that managers and policymakers now have the most complete multi-resource inventory data ever compiled for the same sampling points for all the forest lands in an entire state.

The South Carolina project is a step towards expanding a traditional resource inventory to include wildlife values. At the same time, it is still far from obvious that expansion of multi-resource inventories to include wildlife parameters will yield the best estimates of wildlife needs over the long run. The spatial and temporal patterns affecting wildlife resources may markedly differ from those influencing other resources in a given land area. For example, with migratory species, influences occurring in different regions may have to be assessed to make a meaningful interpretation of wildlife trends. Techniques of integrated ecological assessment need to be considered, in which the guiding concepts and basis for sampling design are identification of information needed to assess each resource component and means of integrating it, rather than collection of all multi-resource data at the same sampling stations.[4]

Analysis and Evaluation

In order for wildlife habitat inventories to be useful as management tools, it must be possible to quantify habitat in relation to its existing and/or potential capability to support wildlife populations. This is the most difficult aspect of the inventory process.

The most direct approach involves actually sampling wildlife species or populations occupying a given unit of the landscape. This is often necessary for site-specific management decisions, such as recommended harvest levels for big game species management. However, direct population surveys are expensive and time consuming. Further, because animal populations are highly variable over time, observations during one or several time periods may not be representative. In addition, the abundance of animals may reflect influences other than direct habitat potential, such as limiting conditions in another portion of a migratory species' range. In some cases existing populations may actually be in excess of the long-term carrying capacity of the habitat.

These difficulties frequently make it necessary to determine the potential habitat value by analyzing the area in relation to the life requirements for food, cover, water, and reproductive habitat of various species. Many approaches are being used. For example, among other techniques, BLM and FS have used the life-form method of Thomas et al. (1976) to analyze wildlife inventory information. This approach was originally developed with wildlife data from forestlands in northeastern Oregon. Recently, the method has been successfully applied to rangelands in southeastern Oregon (C. O. Maser and J. W. Thomas, personal communications). The life-form method uses selected physical characteristics of breeding and feeding habitats to classify hundreds of wild vertebrates into 16 or so life-form classes. These classes can readily be related to plant communities. Since the impact of major management actions on plants are fairly specific, it is possible to predict likely impacts of changes in plant communities on life-forms and hence on individual wildlife species.

FWS has been directing major efforts towards developing, in cooperation with the states and other federal agencies, standard Habitat Evaluation Procedures (Schamberger and Farmer 1978) to be applied to evaluation of water and related land resources projects under the Fish and Wildlife Coordination Act. For many years man's use of the fish and wildlife resources has been used as the sole means by which project impacts were determined, and by which mitigation or compensation features of projects were designed. However, the man-use day did not provide a true assessment of the habitat resource or its value to man. FWS's Habitat

[4]For a review of integrated ecological assessment concepts, see Coulombe (1978).

Evaluation Procedures have been developed in response to the need for methods for evaluating the impact of proposed projects based on the value of the habitat for wildlife.

The purpose of the Habitat Evaluation Procedures is to provide a uniform, quantifiable, nonmonetary assessment of project impacts on fish and wildlife resources. This is accomplished by use of a suitability index determined through a series of ratings and evaluations of habitat attributes. The Procedures are designed to provide an index of existing baseline habitat conditions. The field biologist extrapolates probable changes in the habitat characteristics that will result from the implementation of various potential futures related to either management plans, project designs, or other land use changes that occur as a result of the project. The various futures are compared against the baseline conditions or other alternative futures with or without project to determine the change in the index number, which is a measure of project impacts. Such changes can be determined on either a species or a vegetative class basis.

FWS is working with representatives of other Federal agencies, such as the SCS and the Army Corps of Engineers, on the further development and testing of these procedures for uniform application to federal water development projects.

Interpreting the wildlife values of habitats becomes more difficult when collecting information on a wide aerial scale through remote sensing or other sampling methods, where detailed observations on all individual sites would be too time consuming or expensive. Potential habitat value must then be established based on a more limited set of habitat features. In an attempt to address this need, FWS has been developing a rapid assessment method for inventorying and interpreting wildlife habitat values in large coal bearing regions in the Northern Great Plains, using remote sensing techniques and interpretive measures. Elements of this approach will be described in the panel discussion to follow (Asherin et al. 1979).

For national and regional assessments, a key issue requiring attention is a means of systematically correlating wildlife values with habitat classification systems. For example, the National Wetlands Inventory is systematically gathering information on the extent and distribution of various wetland types in accordance with a hierarchical classification system. The need now is for a systematic method of describing all values (for example, ecological, hydrologic, etc.) associated with each wetlands type. Considerable information is available on the wildlife associated with, or dependent on, some wetlands types and complexes of wetland types; less on others. What is required is a systematic means of structuring and cataloging such information, so that it can be usefully correlated with the information resulting from the Inventory on extent and distribution of wetlands at different levels in the hierarchical classification scheme.

Information Management

In order for large amounts of ecological inventory information to be useful in resources planning and management, development of computerized information systems is necessary. The growing requirements for answers to a continually more sophisticated set of questions for planning and budgeting and evaluation purposes, and the widespread availability of computers and computer skills, are causing reevaluations of agency approaches to information management.

In BLM, for example, most wildlife inventory data are presently being handled manually at individual field offices. However, in 1976 BLM developed a comprehensive plan to guide the agency in establishing a data management system. This plan is termed the Strategic Plan for Information Systems Management (BLM 1976). The initial phase of the Strategic Plan concerning resource inventories is completed and consisted of identifying and defining data elements needed by resource specialists and land managers. BLM is now developing a computerized system to store, retrieve, and display inventory and other resource data. Field offices will eventually use computer terminals to handle inventory information, including the use of interactive graphics.

Increasingly, systems development is emphasizing systems which can store and manipulate large amounts of information on a geographically referenced scale to display spatial relationships for use in planning and decision making. Such systems, properly designed, provide not only means of maintaining and retrieving data, but also powerful analytical tools.

FWS has placed heavy emphasis on development of geobased information systems during the past several years. The focal point for development of these systems is its Western Energy and Land Use Team at Fort Collins, Colorado. A prototype Geographic Information System has been developed which uses computer technology to increase the efficiency with which diverse resource management information such as vegetation, soils, wetlands, and streams displayed in map form can be analyzed by resource managers. A forerunner of this system has been implemented as part of the Alaska Information Management System currently on-line in Alaska and is being used by FWS, BLM, the Corps of Engineers, and other federal and state agencies in various resource planning efforts. The overall strategy is to continue development of this system and to equip FWS Regional and Area Offices with capability to operate compatible systems as rapidly as financial resources permit.

Issues raised by the proliferation of agency information management systems again highlight the need for comparability standards. In a few years, the problem has changed from too little ability to store and manipulate data to one of overlapping and frequently incompatible systems. Doubtless, each resource management agency will require a system tailored to meet its own specific needs, but the key is to assure that the data are interchangeable among systems.

Coordination

Federal Activities

The foregoing discussion emphasizes that coordination of federal wildlife habitat inventories is crucial because of the major data collection efforts anticipated during the 1980s. Table 1 summarizes the four broadest federal efforts currently underway in which information relating to wildlife is collected. The table shows major differences in approach, as well as some common elements, and highlights the need for coordination.

Because each agency is approaching the collection of wildlife information from a somewhat different standpoint, meaningful coordination of inventory activities is difficult. Despite this, much coordination has taken place. Examples are exten-

Table 1. Information related to wildlife habitat collected in four major federal natural resource inventories.[a]

	Forest Service, Forest and Rangeland Renewable Resources Planning Act	Fish and Wildlife Service, National Wetlands Inventory	Bureau of Land Management, Federal Land Policy Management Act	Soil Conservation Service, Soil and Water Resources Planning Act
1. Objective	National assessment	National and regional assessments	Land management planning and resource allocation	National assessment
2. Level of Resolution	Top down, mid-level	Site specific	Bottom up, site specific	Top down
3. Land/water type	Forest, rangelands, and associated waters	Wetlands	Forest, rangelands, and associated waters	Forest, rangelands, croplands, and associated waters
4. Geographic coverage	National	National	11 contiguous western states	National
5. Ownership	Federal, state, private (ownership not distinguished)	Federal, state, private (ownership not distinguished)	BLM only	Non-federal
6. New-existing data	Existing	New	New and existing	Existing
7. Statistical control	None, not a sampling approach	Yes	At most intensive level only	Yes, national and state
8. Classification	Political, by state Ecological, by forest vegetation cover types and range vegetation	Political, by state Ecological, by existing wetland type	Political, by state Administrative, by BLM District Ecological, by soil types and existing vegetation	Political, by state Physical, by soil types and land use
9. Components	Fish and wildlife species occurrence Relation between species and habitat	Acreage by wetland type	Fish and wildlife species occurrence Habitat quality estimates	Correlations with land use, trends, and conditions

Table 1. Continued

	Forest Service, Forest and Rangeland Renewable Resources Planning Act	Fish and Wildlife Service, National Wetlands Inventory	Bureau of Land Management, Federal Land Policy Management Act	Soil Conservation Service, Soil and Water Resources Planning Act
	Cross-linked to acreage in FS timber and range inventories		Acreage of habitat components	
10. Data output and availability	Computerized; available by request	Computerized; maps available by request	Not-computerized, data and maps; reports, available at District Offices	Computerized; available in reports and by request
11. Time frame				
(current)	1975, 1979	1981	1990	1979
(future)	10 year intervals	Continuing	Continuing	1985
12. Compatability among 4 surveys	NWI with FLPMA vegetation	Comparable with RPA, RCA	With RPA vegetation Partially with NWI	NWI

[a]Table shows only information directly related to wildlife habitat; does not include other information on other resources collected as part of these inventories.

sive interagency cooperation in development of the National Wetlands Information, a liaison committee between FS and SCS to coordinate inventory and assessment activities, and many others. The results of some of these efforts are reflected in Table 1.

In June 1978, in recognition of the importance of more comprehensive coordination. BLM, FS, SCS, and FWS signed an Interagency Agreement Related to Classifications and Inventories of Natural Resources. Subsequently, the agreement was expanded to include the Geological Survey, U.S. Department of the Interior. The purpose of the Agreement is to provide for liaison and cooperation in survey, inventory, appraisal, assessment, and planning activities with particular emphasis on renewable resources. Principal objectives are to provide guidelines and to assure administrative action to minimize duplication and overlapping efforts and to enhance and encourage overall data collection, data sharing, appraisal efficiency, program compatibility, and expedite technology transfer. The Agreement provides for coordination in such areas as classification systems, data element definitions, data acquisition procedures, and data exchange.

In beginning to implement the Agreement, agency representatives have decided to limit the scope of their work and to focus initially on development of mutually acceptable inventory standards. Initial efforts have been directed towards development of a classification system to serve as the framework for the various inventories and appraisals. The proposed National Land Classification System serves as a starting point. Work also has begun on a common data element dictionary, utilizing the BLM dictionary as the basis. Development of a problem analysis focusing on identification of information needs has been recognized as a top priority issue, and work on such an analysis is underway. In the future, work will expand to address additional issues, such as those dealing with inventory strategies and procedures, and information management systems.

As agreements are reached on design of compatible systems, work will expand to address the implementation phases, including division of agency responsibilities, location and timing of inventories, budgeting arrangements, and personnel training. A multi-agency staff has been assembled in Fort Collins, Colorado, to develop procedures that are consistent and complementary.

Although participation in the Agreement has been limited initially to five agencies to provide a manageable approach, future participation might include other agencies with related activities and information needs. In any case, the need is recognized to seek advice and comments from other interested parties, both collectors and users, including other federal agencies, state and local governments, and the private sector. If the agencies concerned are successful in achieving their objectives, the Agreement could lead to the first truly coordinated national inventory of wildlife habitat.

State–Federal Cooperation

Coordination of federal wildlife habitat inventories with state activities is a major need. The states have an obvious stake in obtaining such information in relation to their management needs. Because of their key management responsibilities, they must play a major role in conducting inventories and providing wildlife data, and they represent an important source of information and expertise. Most states have developed, or are in the process of developing, information systems for natural and human resources and economic planning. They are a large user of federal systems and contribute much of the information to resource information bases. The impact of uncoordinated federal requests to the state fish and wildlife agencies for the same information, often in different formats, is a common problem.

Each of the federal agencies discussed here has extensive working relationships with its state counterparts, and the states have been heavily involved in such efforts as the RCA, the RPA, and the National Wetlands Inventory. Difficult as it may prove to be to achieve full federal coordination of wildlife habitat inventories, state–federal coordination is even more complex. Not only must wildlife habitat information be coordinated *among* the states if true state–federal coordination is to be achieved, but this must also be related to the need *within* each individual state to relate wildlife habitat information to other natural resources information to other natural resources information activities within that state. As the Council of State Governments (1978:35) has pointed out, "Each state poses a unique configuration of resources, governmental structure, and development concerns that often frustrates federal agencies; they might prefer a single agent for all states, or at least a standard approach that will achieve predictable results across the nation. But state traditions are not easily altered to accommodate federal agencies . . ."

Clearly, there is a need for the International Association of Fish and Wildlife Agencies to play an active role in coordinating state wildlife habitat information activities and in providing an active interface with the federal agencies party to the Interagency Inventory Agreement. In addition, to assure that this coordination takes place within the broader context of state natural resource information activities, an entity such as a recently formed group from the National Governor's Conference concerned with land use and natural resource information systems should also be involved.

However, as yet, there is no overall vehicle for fully integrating federal activities with those of state fish and wildlife agencies.

Summary, Conclusions, and Recommendations

1. Renewable natural resource inventories have increased in scope and importance during recent years, under the impetus of comprehensive environmental and natural resource management legislation. The information stemming from these activities will be of growing national importance in guiding resource policies and programs, environmental assessments, and multiple-purpose planning for the management of federal lands.
2. This trend has stimulated a need for information on wildlife habitats, to support both broad assessments and the needs of site-specific management. Federal wildlife inventories are moving rapidly from an emphasis on surveys individually designed solely to meet site-specific management needs towards a broader, more structured approach. If wildlife is to receive equal consideration with other competing resource uses, it is essential that these inventories be structured to provide a reliable wildlife information base, comparable to that being developed for commodity and other values.
3. Ideally, a national wildlife information base should evolve through a combined federal–state cooperative effort. One such strategy might be development of a long-range plan for gathering wildlife information for both state and federal planning, beginning at the lowest management levels of the agencies involved, from which information could be aggregated to state, regional, and national levels for assessment purposes. Information would be stored in computerized information management systems and would be accessible to various users through computer terminals. The information would then be kept current through continued updating.
4. While it may not prove feasible to achieve such an idealized wildlife habitat information base within the next decade, it is important to strive for as much progress in that direction as possible. Some of the issues and problems that will have to be addressed and overcome are as follows:
   a. There are unresolved conceptual problems concerning the best strategies

and methods for conducting wildlife habitat inventories. These include such issues as means of meshing site-specific, "bottom up" surveys into a larger, "top down" inventory framework. There is no general agreement on the habitat characteristics that should be observed, recorded, and analyzed. With the growing trend towards multi-resource surveys and appraisals, the need remains to identify wildlife habitat parameters to be measured which can assure meaningful consideration of wildlife values. Perhaps most important, reliable means of linking population densities, or even actual species occurrence, with habitat characteristics remain to be developed, particularly in broad-scale inventories.

b. There is currently no fully compatible approach to wildlife inventories among the federal agencies, although active efforts are underway to achieve this. Uniformity of data element definitions, standard scales for conducting surveys at varying levels of detail, and hierarchical approaches to classification and inventory are being explored. Since information requirement and user needs vary within and among agencies, it may not prove feasible to design one single multi-purpose system to meet all needs. If that proves to be the case, emphasis will have to be placed on developing approaches which permit interchange of large amounts of data collected under different approaches and for different purposes.

c. Coordination of state and federal habitat inventories is essential, but poses even more difficult problems. A mechanism is needed to develop coordination among the individual states. This could also provide a focal point for state–federal coordination. The International Association of Fish and Wildlife Agencies appears to be an appropriate organization to address this need.

5. Major efforts must be made towards developing an agreed-upon, conceptually sound framework to guide wildlife habitat inventories, which can be implemented through a coordinated approach. This is needed to assure that wildlife information developed through national inventories and appraisals during the next decade is adequate to support realistic interpretation and analysis of wildlife trends and policy and program needs. In addition, the need to achieve efficiency in a time of declining public budgets stresses the importance of such an approach.
6. We recommend that the International Association of Fish and Wildlife Agencies assign a committee to work with the federal agencies through the vehicle of the Interagency Agreement Related to Classification and Inventories of Natural Resources to develop a coordinated state–federal approach to wildlife habitat inventories. The objective should be to work jointly to resolve technical issues, develop a conceptually sound inventory framework and outline an implementation strategy for collecting and managing the information.

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State Efforts to Inventory Wildlife Habitat

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Introduction

In 1928, Aldo Leopold initiated a game survey "to appraise the chance for the practice of game management as a means to game restoration in the north central region" of the United States. This survey, financed by the sporting arms and ammunitions industry, was designed "to describe game conditions as they exist, the opportunities which those conditions offer, the human machinery available for acting on them, and the probable consequence of their future neglect." (Leopold 1931:5)

Basic survey methods involved compiling and interpreting the observations and experiences of sportsmen, naturalists, scientists, officials and landowners. Some survey methods had to be developed by trial and error; hence, Leopold indicated that the states surveyed last were described best.

Upon completion of the survey in 1930, Leopold concluded "No single statement in this report is offered as final or sufficient fact . . . on the contrary, the whole thought and purpose is to show how much and what interesting work remains undone, and what services to conservation may result from its competent performance. The success of the survey will lie not in how its findings stand, but rather in how quickly they are superseded by more thorough work." (Leopold 1931:5)

Many game species are now surveyed or inventoried; (1) annually, biennally, or at some other convenient time measure, (2) on discrete study areas, on a statewide or regional basis, on a national or international scope, and (3) by using a variety of conventional and innovative techniques. These surveys are accomplished independently or cooperatively by federal, provincial or state governments, fish and game departments, natural resource agencies, state planning departments, universities, and private groups and organizations. Some surveys are conducted to satisfy certain legal requirements while others are initiated with no specific goal or objective in mind.

Over the past several years, there has been a virtual explosion of requirements for "assessing" the status of our renewable natural resources. Some of this has been the result of congressional directives to the various land management agencies and tied in to mandated planning activities. Some has resulted from similar legislative directives at the state level. In addition, a number of academic institutions, governmental agencies and private organizations have developed independent systems for the collection, storage and retrieval of data related to resource conditions. In some instances no data storage-retrieval system is available and the data cannot be effectively utilized.

At the 1978 meeting of the International Association of Fish and Wildlife Agencies, considerable discussion took place on the evolution of these systems and the proper role of state fish and wildlife agencies in contributing to or becoming a part of these systems. Agency heads recognized that up-to-date information on the status of fish and wildlife is needed, not only for state programs, but also for planning work of the major federal land managing agencies.

An agreement has been reached between the U.S. Fish and Wildlife Service, Forest Service, Bureau of Land Management and the Soil Conservation Service to collaborate as necessary in establishing fish and wildlife data needs in connection with their "assessment" programs. This should provide coordination for the major federal agencies but it leaves out the states whose cooperation and assistance is vital to the success of the assessment work. The states are responsible for managing tremendous quantities of natural resources and their policies, programs and plans are well defined. Thus, they should not be ignored nor be given only passing notice in federal planning efforts. The states must be an integral part of any federal effort but, to do so according to federal standards, may well preempt the states' abilities to discharge other essential responsibilities. The fish and wildlife directors concluded that this entire problem needs serious study and constructive resolution.

Thus, in September 1978, Association President Glenn L. Bowers appointed a special ad hoc committee to review the current status of inventory/assessment work by state fish and wildlife agencies, with specific identification of shortcomings and recommendations on what needs to be done to insure collection of useful data without significantly disrupting ongoing state programs. Members of the ad hoc committee included David Brown (Arizona Game and Fish Department), Jerry Gates (New Mexico Department of Game and Fish), Bruce Gill (Colorado Division of Wildlife), E. G. Hunt (California Department of Fish and Game), Steve Miller (Maryland Wildlife Administration), Gary T. Myers (Tennessee Wildlife Resources Agency), Don Brown–Vice-Chairman (Montana Department of Fish and Game), and C. D. Besadny–Chairman (Wisconsin Department of Natural Resources).

The magnitude of the charge and time constraints for preparing a comprehensive report for this conference prohibited the committee from doing a state-by-state analysis of the inventory/assessment problem. Instead, committee members relied heavily on personal knowledge and on contacts with colleagues in neighboring states.

Status of Inventory/Assessment

Several problems emerge in evaluating state efforts to inventory or assess wildlife habitat. The first problem is that wildlife habitat means different things to different people. The basic reason is that there are two fundamentally different approaches to wildlife management. The oldest and simplest is the featured or primary species approach. Currently, this approach means that management projects (including surveys or inventories of animals or habitat) are directed toward species of some economic significance (game, fur or pests) or toward species that are threatened, endangered or unusual in that they capture public attention (i.e., sandhill cranes, timber wolf and pileated woodpeckers).

The newer and more complicated approach is ecosystems analysis. This approach means that management projects (again including surveys and inventories) are directed toward certain aquatic or terrestrial plant communities which are known or presumed to be important to all existing species of wildlife which utilize that particular ecosystem.

The featured species approach requires that an inventory of habitat be specific to the four needs essential to that particular species, i.e., food, cover, water and space. The ecosystem approach identifies no single species but refers to each plant community identified and inventoried as wildlife habitat or, more often, simply as habitat.

The second problem is that a wildlife habitat inventory may be perfectly satisfactory for a particular state but worthless or misleading if used for national, regional or site-specific purposes. The opposite can also be true. A perfectly good habitat inventory on a specific area may not provide useful information on a much broader basis.

The third problem is that it is much easier to obtain information on relatively stable natural resource components such as soils, commercial timber, wetlands and agricultural crops than it is to obtain comparable data on elusive wildlife populations.

Inventory/Assessment Problems

The National Environmental Policy Act (NEPA) of 1970 established that it is a matter of national policy "to enrich the understanding of the ecological systems and natural resources important to the Nation." To this end, in Executive Order No. 11514, President Nixon requested all federal agencies to "Foster investigations, studies, surveys, research and analyses relating to (i) ecological systems and environmental quality, (ii) the impact of new and changing technologies thereon, and (iii) means of preventing or reducing adverse effects from such technologies." The lack of such long-term comprehensive studies, however, suggests that this charge has not been taken seriously.

Similar legislation has been created in many states. Fish and wildlife agencies have since become inundated with requirements for writing impact assessments on public projects, demands for information for use in developing assessments on private projects, and reviews of somewhat biased interpretations of publicly generated data by private environmental consulting firms. The states are the only repositories of wildlife data for most of the lands within their boundaries and state fish and wildlife agencies are most knowledgeable of their natural resource capabilities. Hence, they must deal directly with each assessment problem.

Another phase of the assessment program involves the adequacy of wildlife population and habitat inventory methodologies. Problems in this area revolve around three questions. First, to what degree of resolution do we need information on wildlife habitats and populations? Problems of obtaining accurate estimates are certain to be different if information is required on specific herds or geographic populations in contrast to statewide population levels.

The second question is—how precise must the information be? Precision of 100 percent cannot be achieved. That leaves us with some kind of estimate of population and habitat abundance or at least of relative abundance (Jackson 1978). Levels of precision of those estimates are determined by the amount of fiscal and personnel resources the funding agency can realistically commit to the inventory processes.

The third question is—how frequently do we need to know or how often must the inventories be repeated? Do we really need to know the population size of a wildlife species every year or do we need to evaluate habitat every year? Again, availability of resources is likely to temper our perception of need.

Given these three interrelated questions which wildlife population and habitat inventories try to address, what are some of the pitfalls and inadequacies of current inventory systems? First, most wildlife inventory efforts, at least of state fish and wildlife agencies, have opted for indexes to relative animal abundance rather than attempting to estimate absolute densities. Reasons for this are that estimates of absolute densities for uncommon or cryptic species are difficult and costly. In many instances, agency personnel do not know enough about species ecology and behavior to develop accurate census methodologies. Thus, agencies opt for some method that can be executed (i.e., sage grouse strutting ground counts, mourning dove coo counts, snap trap capture indexes for small mammals, etc.) without establishing a relationship between chosen indexes of abundance and real abundance.

Similar problems are encountered in habitat inventories. For years, western wildlife managers have evaluated the adequacy of deer winter ranges on the basis of production and utilization of selected "key" shrub species on selected "key" wintering areas. It has been assumed, but never demonstrated, that these measurments reveal something about the adequacy of those habitats to support deer. Available evidence arouses suspicions that these inventory systems are irrational from the perspective of deer welfare (Gill 1976).

The need, then, is to decide what should be measured and to what scale. Next, the best available technique must be chosen to provide reasonably accurate information. If none exists, we must be objective enough to admit it and put our research staff to work developing workable techniques. In the interim, we still need to put acceptable information into the assessment processes. This information should be based upon our best empirical knowledge with no apologies offered. However, we must maintain the realization that our data generation systems must continually be improved and with it, the need for automated data storage and retrieval becomes self-evident.

A major related concern is that few wildlife and habitat inventory systems are based upon sound sampling theory. A frequently ignored, but critically important, reality of mensuration systems is that sampling measurements pertain only to the samples that are measured. Any extrapolation beyond the sample to apparently similar, but unmeasured, individuals or attributes is conjecture. If a sample is obtained in such a way that we cannot numerically qualify the probable validity of the extrapolation, then we have no idea of how representative the sample might be. To avoid this pitfall, all inventory systems should be based upon sampling theory. The risks of extrapolation can be examined and the quality of the data evaluated and recorded.

Another problem, at least with inventory systems of state fish and wildlife agencies, lies in what Bruce Gill of Colorado calls the "inertia of the status quo" (Gill, personal communication). Most of our existing inventory systems evolved in response to a demand to regulate harvests of game species. Because there were annual hunting seasons and there was an immediate need to forecast annual harvestable surpluses, annual inventories of wildlife and habitats were developed.

The time is ripe to ask why we now need to inventory every year or even if we ever did. Fiscal and personnel resources could be stretched much farther or other priority activities undertaken if the inventory interval for any one area of interest was lengthened to every 5 or 10 years. Perhaps simulation technology could provide sufficient information on the likely state of the system in unmeasured years. These simulations could be recalibrated each time new measurements are taken.

Many of our inventory systems have attempted to measure attributes of herds or recognizable populations of wildlife. Again, this probably resulted because of game harvesting systems. This has produced reams of published "herd study" articles. Thus, we have information generated to describe how a specific population in a specific locale at a specific location behaved. The information has not been very useful to forecast how that species in general might respond at a different time in a different place. We have not assumed an ecological perspective in much of our wildlife science, but rather a demographic perspective. If fish and wildlife agency administrators are to meet the demands imposed by the new "environmentalism," we must begin by changing our emphasis from "herds" to "ecosystems."

Finally, what's wrong with the general assessment process? The formalized process of environmental impact statement preparation grew out of the requirements of NEPA. Perhaps one of the most extreme arguments against NEPA and its positive impact on the environmental movement was presented by Fairfax (1978). She argued that the attention focused on NEPA and its "paper" solutions to environmental problems diverted public attention away from antecedent legal solutions which were evolving in the courts with the result that the potentially potent weapon of environmentalists was prematurely defused and replaced with a NEPA paper tiger. Perhaps this viewpoint is justified if NEPA is considered by itself. However, when considered as a part of the total body of environmental legislation, it's hard to deny that NEPA has made a contribution.

More exacting criticism of the assessment process was leveled by Schindler (1976), who charged that environmental impact statements have been retrogressive to the environmental protection movement because they spawned a generation of instant ecologists with an armada of gray literature insulated from scientific peer-group review. This argument has considerable substance because the most critical attribute of science is credibility of scientists. Part of the current problem is that NEPA requires an evaluation of our activities on environments we know very little about (Commoner 1970). Fish and wildlife agencies have responded by trying to be as quantitatively specific as possible in trying to forecast the direction and magnitude of those impacts. But most agencies have done so with something less than total objectivity. Most state agencies at least have generally approached impact statements with the attitude that all impacts are going to negatively affect wildlife and have set about to amass numerical arguments against the proposed impacting activities.

In our zeal, we have failed to distinguish between what is fact and what we suspect as experienced professional resource managers. This has blurred the distinction between fact and opinion in impact statements to the point where these statements appear far more knowledgeable than they are. Impact statements would be far more useful if they drew very distinct lines between areas where there is sufficient information to be confident of predicted outcome and areas where impacts can only be guessed at. These distinctions would serve the dual purpose of highlighting for decision makers the areas of "hard" and "soft" knowledge so they could better understand the risks associated with decision. This approach would also pinpoint areas of needed surveys and research. A second failing of assessments is that so far we have failed to take a systems approach to the problem. Several writers have described and recommended systems approaches to environmental impact statements (Cantilli et al. 1978, Odum 1968 and 1977, Welch and Lewis 1976, Patten 1978, Van Dyne 1978). However, as yet there have been few serious applications of these recommendations.

Decision Making

The use of wildlife habitat inventory data in decision making varies widely. Resource managers in the field need specific data for site planning or for developing management plans for a proposed project. Resource administrators frequently settle for statewide or regional data to help shape policy or program decisions. Politicians sometimes utilize statewide or national information or they may rely on material provided by bureaucrats or special interest groups.

With the objectives of the Fish and Wildlife Coordination Act, national and state environmental policy acts, the Land and Water Conservation Fund Program and the need to satisfy various federal and state permit requirements, wildlife inventories are becoming increasingly important. The weak link, however, is the availability of accurate wildlife population data and time constraints in the assessment review process. Private consultants and federal agencies spend months or years gathering resource information and reviewers are requested to make an intelligent analysis and respond to the implied impacts in 30 to 45 days. One step in the right direction is that the 1978 United States Endangered Species Act requires critical habitat identifications to be made by the Secretary of the Interior in consultation with states, rather than by the Secretary alone, as in the 1973 Act.

When an information data vacuum exists, most small-to-medium size projects (i.e., shopping centers, subdivisions, small impoundments, etc.) are evaluated on the basis of existing information. Large projects, such as siting of electric generating facilities or building of new highways, require gathering of substantial data and usually include initiation of detailed studies on wildlife populations and their habitat.

Because most impacts on wildlife habitat are the result of cumulative effects of numerous small-to-medium size projects, the need for rather comprehensive and complete regional or statewide inventories is essential. The regulatory framework exists for mandatory consideration of wildlife impacts in decision making at all levels. However, for the majority of proposed projects, detailed and current information must exist at the time the project is proposed if wildlife considerations are to have a meaningful role in the decision-making process.

While federal and state agencies generate large quantities of information for government-sponsored projects, consultants and private organizations also produce considerable information to comply with various regulatory requirements. To date, most of the studies undertaken across the country are not coordinated by any single agency nor do they fit into any framework of national, or even statewide, data collection, storage or retrieval system. In addition, studies by some consultants are suspect, especially when inventories or surveys are conducted using unconventional methods or substandard techniques.

Any analytical study designed to help decision makers identify the proper course of action needs a systems analysis. If the role of the wildlife manager is to conserve or protect the wildlife resource for the benefit of the people and the role of opposing forces is to develop other resources for the benefit of the same people, then both must operate from a common source of knowledge if the best alternative course of action is to be chosen. Systems analysis attempts to look into the complexities of the problem—objectives, cost, effectiveness, impacts and alternatives. The ingredients are not new but the approach provides for an interdisciplinary systematic look at all problems and it does recognize the uncertainties of the data base. Any analysis must be broad enough to include the problems of all interacting forces and recognize that all data are not equal.

In most cases, the intuitive judgment of one or more resource specialists, coupled with their academic and field knowledge, would be adequate or at least would suffice for the present and, hopefully, allow time for a program to supplement the weak spots. Subsequently, a way will be found or a method developed to obtain more specific knowledge if it becomes practical to do so. Inventory/assessment work by state fish and wildlife agencies will always have shortcomings; for example, today's inventory is obsolete immediately if it must be quantified with the precision of the cost of moving a yard of dirt. On the other hand, any knowledgeable resource manager can hang tough if he or she takes a positive approach and enumerates what is known. A problem arises when the manager becomes deliberately ambiguous in an attempt to stall proceedings. Statements like "we do not have adequate information to answer those questions," or "we will not be prepared to furnish that data until we complete a five-year study," cannot be successfully used in today's search for alternative courses of action.

However, the real problem is that even if all the information were available in a multitude of reports (some obscure), what agency can afford a diversified group of professionals to interpret each report?

Most wildlife reports deal with a species or group of species and their habitats. Assume for the moment that the resource managers in each state, who are knowledgeable of past reports in their area of responsibility, record salient information on a standard form that all other disciplines can relate to. This would be a great step forward. Pride and time will correct the errors and upgrade the data.

Several states have completed or are nearing completion of a strategic wildlife plan and are developing data collection, storage and retrieval systems. Montana's first strategic plan was completed in 1975. It was based on the above assumptions and the theory of self correction is working. It utilizes a standard method of displaying species and habitat data. The Montana data bank remains open and the information is flowing into it.

Maryland is developing a wildlife information data retrieval system which includes a dynamic habitat inventory feature. This system will be administered as a subprogram of the Maryland Automated Geographic Information (MAGI) System. MAGI, a data bank and computerized system, was initially utilized to generate computer maps displaying the capability and suitability of land for various uses across the state. The data storage feature allows for the retrieval of any habitat variable combinations desired by the investigator and does not limit the investigator to the constraints of a rigid classification system.

Arizona and New Mexico have a computerized data base program called "Run Wild" which is available through the United States Forest Service. Categories of data in this bank include: vegetation types, list of species, list of habitat factors, animals needing habitat factors, animals needing vegetative types, management information relating to each species, literature references and species by county. Although the program is in use, it has not been fully tested.

A common flaw in developing a standardized habitat classification scheme, however, is that the method is usually developed first and then it is evaluated as to which objectives it can assist in achieving. Any habitat inventory or classification scheme is a tool. This tool must be designed to accomplish a pre-established objective.

The development of a habitat inventory system for statewide, regional or nationwide problem solving also must be oriented toward a stated objective. When new habitat inventories of large scope are being planned, communication between potential users of the data is paramount. Not only will contributions toward a stated objective be achieved, but other users may be advanced simply because the data were obtained in a format comparable to existing data. Through interagency communications, the cost efficiency factor of the project is advanced.

Since the discontinuance of the United States International Biological Program studies, there has been a void in ecosystem studies. We need to revive these efforts. The Federal Government, through the National Science Foundation and the United States Fish and Wildlife Service's Pittman–Robertson and Dingell–Johnson programs, should take the lead in encouraging ecosystem level fish and wildlife research.

The states need to free themselves from their narrow game species-hunting orientation and begin to look at wildlife as components of larger ecological systems. This will require drastic shifts and reorientation of biological and research staffs, but that reorientation is long overdue. The universities must resist being "bought" by the easy accessibility of federal and private environmental dollars aimed narrowly at specific projects or project-oriented problems and become more directly involved in ecosystems studies.

We also need to forge a new triumvirate of cooperation among the universities, the Federal Government and the state fish and wildlife agencies to develop a standardized inventory/assessment procedure and a computerized data storage bank which can be used by all governmental agencies. Without a standardized and coordinated approach, the states and the Federal Government will continue the expensive, piecemeal approach to inventory/assessments. The International Association of Fish and Wildlife Agencies, with its membership covering both federal and state agencies, should take the lead in coordinating these efforts.

Conclusions and Recommendations

In reviewing the current status of state inventories and assessments, several conclusions are apparent:

1. Inventory methods vary from state to state making comparisons of trends of similar wildlife species difficult or impossible.

2. There are no regional or national standard methods for data gathering, storage and retrieval, although several states have recently implemented new "systems."
3. States have different organizational structures and legislative authorities for carrying out resource management programs so information that is gathered may be obtained in a fragmental manner within and between agencies.
4. Adequate funding, agency needs, wildlife population levels, an intermix of federal and state programs and assessment requirements of various federal and state laws all contribute to the inventory/assessment problem.

These four conclusions lead to four recommendations for action:

1. A systems analysis approach to problem solving is essential, and must be developed and used by all decision makers to identify the proper course of action.
2. Wildlife inventory/assessment work must use standardized methods and yield data retrievable from a computerized data storage bank.
3. The Federal Government should take the lead in encouraging ecosystem level fish and wildlife research conducted by universities and governmental agencies.
4. The International Association of Fish and Wildlife Agencies should take the lead in standardizing the inventory/assessment process and in coordinating efforts to develop a computerized data storage bank which can be used by all governmental agencies. These efforts could be most effectively implemented by the Association's regional organizations through a series of workshops.

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Evaluation of Wildlife Habitat Inventories of Federal, Provincial, and State Governments

Appraising Four Field Methods of Terrestrial Habitat Evaluation

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Answering a recommendation from the National Coordinating Committee for Fish and Wildlife Conservation in the Federal Water Development Programs, the U. S. Fish and Wildlife Service moved to establish, refine, and implement a system of habitat evaluation procedures (HEP) based on non-monetary measures of habitat values. For a better understanding of the collection of habitat information, the Missouri Cooperative Wildlife Research Unit undertook research in 1977 to assess individual observer performance when using four methods of habitat evaluation: (1) U. S. Fish and Wildlife Service (1976) Habitat Evaluation Procedures (HEP) Form 3-1101; (2) *A Handbook for Habitat Evaluation Procedures* (Blue Handbook) (Flood et al. 1977); (3) Line Chart (Whitaker et al. 1976); (4) Matrix Method (unpublished material developed by Ellis, Farmer, Konkel, and Korte; see Ellis et al. 1978). All these methods can be used with the U. S. Fish and Wildlife Service Habitat Evaluation Procedures to provide habitat-quality ratings for selected wildlife species.

Objectives of the study were: (1) to determine whether seasonal differences in scoring existed for each evaluation method, (2) to determine whether prior scoring of test sites using the same evaluation method, or prior *operational* experience in habitat evaluation affected scoring performance, (3) to determine the ability of observers using Line Chart and Matrix methods to estimate certain site characteristics accurately, and (4) to appraise time required for each evaluation method.

Study Area

The study was conducted on or near the University of Missouri Ashland Wildlife Area, Boone County, Missouri. Three old field and three upland hardwood forest sites, each approximately 2 ha, were selected. The six sites spanned a wide range of successional types from recently abandoned cultivated field to mature oak–hickory forest (Ellis et al. 1978).

The number of sites and the order in which they were visited were dictated by logistics, and remained constant for each test period. Boundaries were clearly marked, and participants were instructed to evaluate only the area within the site boundaries.

Methods and Procedures

Test Periods

Five field tests were conducted; one each in June, July, September 1977, and January and March 1978. The HEP Form 3-1101 and Blue Handbook were used in all five tests, Line Chart in the last four tests only, and Matrix in the last three. Tests were conducted on three consecutive days of each period.

Test Participants

Ninety-seven biologists from 13 state, federal and private agencies, from several geographic areas, and with a variety of professional backgrounds participated in the tests. Each participant was assigned one of the four evaluation methods and used it exclusively in all field tests. General instructions were given at the beginning of each test day. Participants produced estimates of habitat characteristics or scores for evaluation elements from what they saw while walking over each test site. Each biologist evaluated test sites only once during each period, but several participated during more than one test period.

Evaluation Methods Tested

HEP Form 3-1101. This method is oriented toward wildlife species. The form displays the evaluation elements (species or groups of species) in columns, and the evaluation sites in rows. As we tested it, HEP Form 3-1101 was a totally subjective method of habitat evaluation, without written criteria. Each test participant assigned a score on a scale of 0–10 for each evaluation element.

A Handbook for Habitat Evaluation Procedures (Blue Handbook). This method is also wildlife species oriented. Species are grouped (e.g., Forest Game—white-tailed deer and wild turkey), and life history information is presented for each group. Written criteria are presented on ten-point or five-point scales, and a formula for combining the resulting scores is provided.

Line Chart. This method requires the user to estimate vegetative characteristics. Instructions and definitions of key terms are provided. Each estimate is entered as a slash (numbered to identify each site) on a scaled horizontal line. Estimates are later translated into scores on a scale of 0 to 10, for various wildlife species (Schamberger and Farmer 1978).

Matrix Method. This method, like the Line Chart, is an objective, vegetatively oriented method, complete with instructions and definitions. Estimates of habitat characteristics for each site are entered in a grid or matrix. Habitat characteristics are shown in columns; test-site numbers and estimates are entered in rows. Estimates later undergo translations identical with those for the Line Chart.

Special Testing Procedures

To facilitate statistical testing we required each participant to assign scores independently regardless of evaluation method used. In actual HEP practice, a team of biologists representing affected agencies first agrees upon specific habitat criteria for each wildlife species. Site evaluations are then made, and team scores recorded on HEP Form 3-1101.

Results and Discussion

Seasonal Scoring Differences

To determine whether there were seasonal (i.e., test period) differences in scoring by each evaluation method, observers' habitat scores for deer, quail, rabbit, and turkey were examined for consistency within each season and for differences between seasons.

Coefficients of variation (CV) for scores resulting from use of the Matrix, Blue Handbook, and Line Chart were relatively low (range: 6–39), inferring consistency in scoring for each test period. This was not true for scores derived from HEP Form 3-1101. These CV's (range: 28–90) suggested that consistent scoring during any test period for this method was improbable.

Mean scores derived by the same methods were examined for seasonal trends. Scores differed according to season (examples in Figure 1). For all evaluation methods, except for two Matrix cases, mean scores were lowest in January for all species considered. Low January mean scores may imply that participants had difficulty assessing sites under winter conditions (snow cover, no foliage).

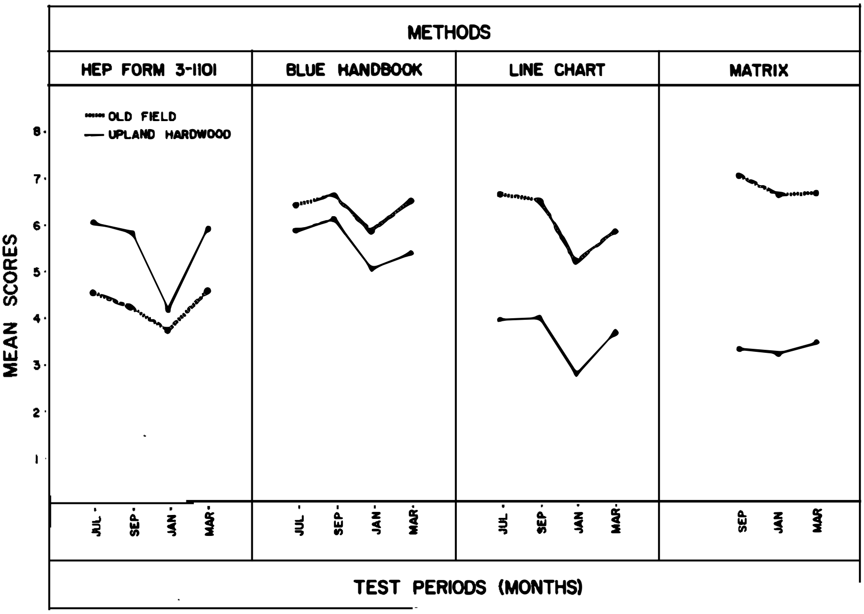

Figure 1. Seasonal trends of mean scores for deer/forest game in old field and upland hardwood sites for all methods.

Scores were tested for differences between seasons by one-way analysis of variance (ANOVA), and pairs of means were then compared by least significant differences (LSD) (Table 1). The two pairs of means with the greatest number of significant differences ($P < 0.05$) for the HEP Form 3-1101, Blue Handbook, and Line Chart scores were July–January and September–January. No significant differences existed between July and September scores for any of the methods. It appears that seasonal differences in scoring were attributable to low mean scores in January.

Percentages of paired means differing significantly were greatest for Line Chart, intermediate for Blue Handbook and HEP Form 3-1101, and lowest for the Matrix (Table1).

Effects of Experience on Scoring Performance

Prior experience with test sites and evaluation methods. We hypothesized that participants experienced in our testing procedure might recall earlier scores or site characteristics and let these influence new scores. To test the hypothesis, we averaged the scores assigned by first-time participants and those assigned by experienced participants for all species and all test periods according to habitat type. These mean scores were subjected to one-way analysis of variance with type of participant (first-time or experienced) as the treatment. Analyses were made separately for each evaluation method.

No significant differences ($P > 0.05$) were found among mean scores of first-time and experienced evaluators, regardless of vegetative cover type evaluated or method used (Ellis et al. 1978). Therefore, participants were not demonstrably biased in scoring sites they had already seen.

Prior official experience in habitat evaluation. We tested the hypothesis that an evaluator's scoring was affected by prior participation elsewhere in official (operational) habitat evaluation procedures. Participants who had performed evaluations using either federal or state procedures and regularly evaluated habitat were considered experienced. All others were considered inexperienced.

Figure 2 depicts the mean scores and coefficients of variation (CV) of experienced and inexperienced participants using each evaluation method. Experienced

Table 1. Comparison of all differences ($F > 1.50$) between pairs of seasonal mean scores for each species, site, and habitat type (LSD).

Evaluation method	No. of pairs of means considered[a]	No. of pairs of means differing significantly						Paired means differing significantly (% of total)
		Jan.-Mar.	Jul.-Jan.	Sep.-Jan.	Mar.-Jul.	Mar.-Sep.	Jul.-Sep.	
HEP Form 3–1101	126	3	5	5	0	1	0	11
Blue Handbook	72	2	5	5	2	2	0	22
Matrix Method	72	0	No data[b]	2	No data[b]	2	No data[b]	6
Line Chart	144	2	15	15	7	7	0	32

[a]Numbers of evaluation elements (animals species) × sites × season combinations.
[b]Martrix testing began in September 1977.

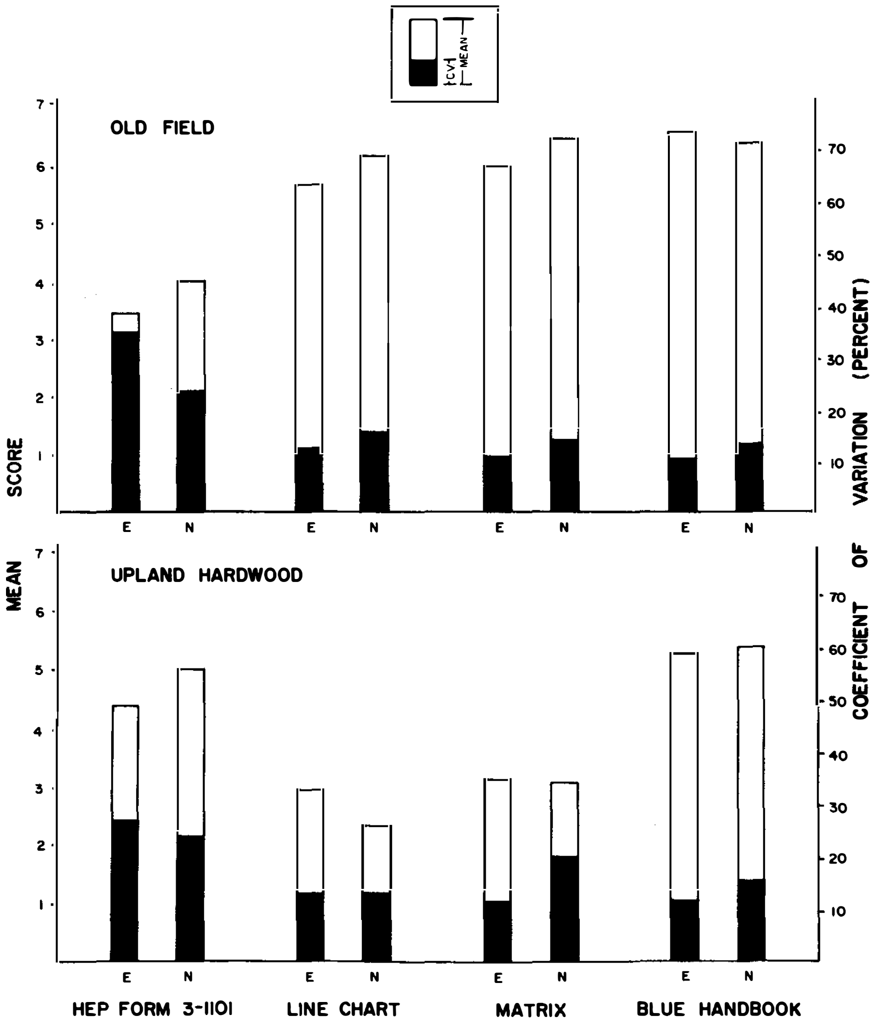

Figure 2. Mean scores and coefficients of variation, experienced (E) and inexperienced (N) participants, for old field and upland hardwood test sites, all test periods.

participants using the HEP Form 3-1101 produced scores with the CV of 35 (old field) and 27 (upland hardwood); scores assigned by inexperienced participants resulted in CV's of 27 (old field) and 24 (upland hardwood). In all other evaluation methods the CV's were lower for experienced participants, ranging between 10 and 13; and between 13 and 20 for inexperienced participants. These CV values suggest that participants using the Line Chart, Matrix and Blue Handbook, but not HEP Form 3-1101, produced consistent scores regardless of experience.

Significant differences (ANOVA, $P < 0.05$) were found between mean scores in old fields of experienced and inexperienced participants using the HEP Form

3-1101 and Blue Handbook (Ellis et al. 1978). No significant differences according to experience were found in mean scores from old fields for the Line Chart and Matrix, nor between means of the two groups in upland hardwoods for any method.

A factor probably affecting results was the more subjective, less structured nature of HEP Form 3-1101 and the Blue Handbook. Experienced biologists acquainted with subjective procedures may have advantages over biologists without comparable experience. The more regimented methods (Line Chart, Matrix) may have decreased the experienced biologists' advantages.

Accuracy of Judging Site Characteristics

Major habitat characteristics used in Line Chart and Matrix methods were measured in detail by project staff members at each study site following the September test period. Resulting baseline data were compared to test participants' entries on field forms, to (1) identify characteristics that could or could not be estimated accurately by test participants, and (2) to compare the accuracy of estimates made by Line Chart vs. Matrix methods.

Estimation of characteristics. Timber types and percentage of canopy closure were usually recorded correctly by participants using both Line Chart and Matrix (Table 2). Other parameters were estimated less accurately. Inaccuracies stemmed from two related problems: (1) some characteristics were intrinsically difficult to estimate and (2) some criteria were subjectively worded.

Examples of characteristics difficult to estimate were the percent of dead trees in the overstory, and numbers of species in the understory and ground cover (Table 2). Such characteristics are biologically important, and to us the criteria seemed adequately worded on the field sheets. It may not be possible for most observers to estimate certain characteristics quickly. Brief on-site reviews including plant identification would be helpful in alleviating the problem. A simple belt transect across a site would provide accurate information on the overstory, understory, and ground-layer plant species. Litter and its components could also be estimated at this time. It is imperative that the transect sample a large enough area to make accurate estimates possible.

The related problem involves subjective wording such as "common." For our purposes, a species was considered "common" if it comprised at least 5 percent of the total plants present of its type (grasses, forbs, etc.). The general failure of participants to estimate "common" occurrence accurately when using either the Matrix or Line Chart methods (Table 2) shows that evaluation criteria should be explicit and supplemented by specific definitions in an accompanying glossary. They should not be too broad (e.g., "overstory trees: percent soft mast species" should be subdivided, as "overstory trees: percent sugar maple" and other similar categories).

Line Chart vs. Matrix estimates. Biologists using the Line Chart and Matrix methods estimated correctly (within 95 percent confidence limits) 46 and 63 percent respectively, of forest site characteristics, based on comparison of their estimates with baseline data (Table 2). Fewer criteria were available for evaluation of accuracy for old field sites, but the Matrix method was again more accurate. Participants using Line Chart were able to assess 33 percent of the criteria cor-

Table 2. Comparison of upland forest characteristics as measured in September 1977 (μ), and as estimated ($\bar{x}$) by test participants using Line Chart and Matrix criteria.

	Line Chart (n = 16)						Matrix (n = 15)					
	Sites											
	1		2		3		1		2		3	
Evaluation criteria	μ	$\bar{x}$	μ	$\bar{x}$	μ	$\bar{x}$	μ	$\bar{x}$	μ	$\bar{x}$	μ	$\bar{x}$
Timber type (coded)	6.0	5.9	6.0	5.9	6.0	5.7	6.0	5.5	6.0	4.9*	6.0	5.2
Percent canopy closure	82.0	83.3	72.0	67.0	76.5	66.6*	82.0	76.1	72.0	71.0	76.5	65.0*
Average dbh of all trees (in)	9.0	10.8	5.8	7.4	8.1	9.9*						
Average dbh of overstory trees (in)							13.4	12.6	8.4	7.7	12.7	10.9*
Overstory trees: percent oaks	92.0	82.9*	78.0	88.2*	84.0	78.4	92.0	90.3	78.0	95.3*	84.0	85.0
Overstory oaks: percent white oaks	84.0	70.5*	75.0	72.0	66.0	87.0*	85.0	77.9	75.0	79.3	66.0	69.1
Overstory trees: percent hickories	3.0	12.1*	4.0	9.4*	3.0	9.4*	3.0	5.6	4.0	3.4	3.0	3.1
Overstory trees: percent walnut	1.0	2.1	0.0	1.3*	5.2	4.5	1.0	1.5	0.0	0.0	5.2	3.3
Overstory trees: percent soft mast spp.	1.0	6.0	7.0	7.3	7.1	10.5	1.0	2.5*	7.0	0.9*	7.1	6.9
Number of common soft mast spp. in overstory	3.0	1.9*	6.0	1.7*	3.0	4.0						
Overstory trees: percent nondeciduous	0.0	0.6	1.0	0.9	<0.1	1.5*	0.0	0.0	1.0	0.4*	<0.1	0.0
Overstory trees: percent dead trees	3.0	4.3	7.0	3.5*	<0.1	6.4*	3.0	3.3	7.0	2.3*	<0.1	4.3*
Number of small openings/100 m	2.0	1.9	2.0	2.6	2.0	3.6*	2.0	3.0	2.0	2.5	2.0	2.9
Number of common understory spp.	10.0	4.7*	5.0	5.7	6.0	6.7						
Number of all understory spp.							10.0	7.8*	9.0	7.1*	11.0	10.0
Number of common soft mast spp.							3.0	5.5*	3.0	4.9*	8.0	7.7
Number of common ground layer spp.	7.0	5.6*	7.0	8.9*	3.0	10.3*						
Number of all ground layer spp.							30.0	13.7*	35.0	15.1*	42.0	21.5*
Number of small mammal runs/m^2	8.0	0.7*	4.7	0.8*	3.4	0.8*	8.0	0.4*	4.7	0.4*	3.4	0.9*
Percent leaf and needle litter	90.0	84.8	88.0	74.5*	81.0	72.9*	90.0	90.9	88.0	87.2	81.0	83.1
Percent log and stick litter	8.0	13.6	10.0	11.9	12.0	14.6	8.0	7.5	10.0	6.1*	12.0	8.1
Percent all litter	99.0	91.5*	99.0	84.6*	98.0	84.5*	99.0	98.2	99.0	92.9	98.0	91.7*
Percent rock	1.0	3.3*	1.0	3.8*	5.0	8.3*	1.0	1.3	1.0	0.7	5.0	4.6
Percentage of mean estimates correct		52.6		47.4		36.8		73.7		47.4		68.4
Overall percentage correct (all sites)				45.6						63.2		

*Asterisk denotes true value (μ) falling outside the 95 percent confidence interval of the estimated mean ($\bar{x}$) for each characteristic.

rectly in September, while those using the Matrix method achieved 58 percent accuracy (Ellis et al. 1978). It should be noted that some criteria were not directly comparable between systems in this analysis.

We made additional checks of accuracy of Line Chart vs. Matrix estimates. We compared baseline values with test estimates for criteria that did not change from season to season, and were common to both methods. We used September, January and March test estimates. In this comparison, too, higher percentages of accurate estimates were made with the Matrix Method (73 percent) than with the Line Chart (59 percent) (Ellis et al. 1978).

Differences in Line Chart and Matrix format may have been partly responsible for the greater accuracy of Matrix estimates noted above. On the Line Chart, slash marks are entered along a single criterion "assessment line" for all sites evaluated in a single day. Even if a correct estimate is made, there is a possibility of entering it incorrectly on the assessment line. On the Matrix form, actual numerical estimates are entered.

On the Line Chart, there may be a tendency to compare subsequent sites to the first site, rather than evaluating each site independently. If the first site is scored incorrectly, the error may be compounded. In the Matrix method, participants may make site comparisons, but because of the display format they are not as prone to do so as in the Line Chart Method. On the Matrix field form, rating criteria appear on a diagonal axis, and estimate rows are horizontal; therefore, estimates for each site are entered on separate rows. Such a format may encourage the participant to concentrate on the site, rather than on prior scores.

Time Expenditures Compared for Four Evaluation Methods

Usefulness of any of the evaluation methods tested would be affected if the method required markedly less or more time in the field or in transformations performed in the office than other methods.

Field time requirements. To determine time required in the field, we asked all participants to record starting and stopping times at each site. The mean time per evaluation for the Blue Handbook was 16 minutes, 17 minutes for the HEP Form 3-1101 and Line Chart, and 19 minutes for the Matrix. However, field scoring times analyzed separately (t-test) for upland forest and old field sites in all possible combinations showed no consistent patterns (Ellis et al. 1978).

Office time requirements. We made no measurements of office time required of the various evaluation methods. However, it is apparent that the HEP Form 3-1101, Matrix Method and the Blue Handbook require little effort after the field work is completed. Values can be taken directly from field sheets, keypunched, and submitted for analysis. Line Chart field forms require additional interpretation of slash marks on "assessment lines" before values are produced for analysis.

Comparison of Evaluation Methods: Conclusions

Relative merits of the four evaluation methods based principally on results of our tests, are ranked subjectively in Table 3.

Table 3. Relative ranking of four evaluation methods according to attributes examined (1 = best).

Attributes of evaluation method	HEP Form 3-1101	Blue Handbook	Line Chart	Matrix Method
1. Seasonal differences in scores	Not ranked (see text)	2	3	1
2. Effect of prior scoring experience				
A. Familiarity with evaluation method and site	1	1	1	1
B. Experience with official HEP scoring	3	2	1	1
3. Accuracy of field estimates of site parameters	No data	No data	2	1
4. Time expenditures				
A. Field	2	1	2	3
B. Office	1	1	2	1
5. Pooled variance	3	2	1	1

Seasonal Differences

Mean scores differed according to season for all methods, but it appears possible to evaluate habitat with the Blue Handbook and Matrix during any season. The Matrix Method was rated number one because there were fewest significant differences between seasonal pairs of mean scores (4 of 72) when this method was used. The Blue Handbook was ranked second. The Line Chart was ranked third with respect to seasonal scoring: 46 of 144 paired means differed significantly according to test period. HEP Form 3-1101 scores were too variable to draw accurate conclusions from statistical testing, and the method was not ranked.

Scoring Experience

We demonstrated no significant difference between scores assigned by first-time participants and those assigned by participants evaluating the same sites, using the same evaluation methods for the second, third or fourth times. Thus, all methods were accorded first rank in this respect (Table 3).

Participants with prior experience in official habitat evaluation produced significantly different mean scores for old field sites than those produced by their inexperienced counterparts, when using the HEP Form 3-1101 or Blue Handbook methods. No significant differences in scoring were observed for experienced and inexperienced participants using Line Chart or Matrix methods. For these reasons the Line Chart and Matrix methods were both accorded number one rankings, and Blue Handbook and HEP Form 3-1101 second and third rankings, respectively (Table 3).

Accuracy of Estimating Vegetative Characteristics

Estimates from Line Chart and Matrix methods were compared with characteristics of the test sites measured in September. Problems of two related types emerged: (1) some characteristics were difficult to estimate visually; (2) some criteria were too subjectively worded.

Participants using the Line Chart in the September field tests estimated correctly (within 95 percent confidence limits) 46 percent of site characteristics in upland hardwoods and 33 percent in old fields. The comparable figures for Matrix scorers were 63 percent, and 58 percent, respectively. For selected criteria, estimates from September, January, and March tests were Line Chart 59 percent correct, and Matrix 73 percent. Therefore, the Matrix Method was ranked first with respect to accuracy, and the Line Chart method second.

Time Expenditure

Field time. Pooled data indicated slightly smaller mean time expenditures for Blue Handbook and slightly more for Matrix field scoring than for the other methods. Our rankings reflect these differences (Table 3).

Office time. The Line Chart requires the greatest amount of office time, because transformation of field sheet marks to numerical values is required. Accordingly, we ranked HEP Form 3-1101, Matrix and Blue Handbook first, and Line Chart second with respect to office time expended (Table 3).

Variance Comparison

A final measure of usefulness is afforded by comparisons of the variance for each evaluation method. This variance was obtained by pooling all variances computed from scores for a given test period, test site, and evaluation element. For example, a variance was computed using only those scores for the January test period, Forest Site No. 1, and evaluation element white-tailed deer. The variance for all other combinations of test period, test site, and the four evaluation elements were computed in a similar manner. These variances were then pooled for each evaluation method. The pooled variance reflects differences due only to evaluation method, since the effects of test period, test site, and evaluation element have been removed. Although the evaluation methods are not strictly comparable, the pooled variances provide a relative measure of the precision of the four methods. Pooled variances were: Line Chart, 0.94; Matrix Method, 1.08; Blue Handbook, 1.49; and, HEP Form 3-1101, 3.07. On this basis, we ranked the Line Chart and Matrix methods first, Blue Handbook second, and the HEP Form 3-1101 third (Table 3).

Judgment

In effect, we compared a subjective habitat evaluation method (represented by HEP Form 3-1101), with objective evaluation methods using written criteria (represented by the Blue Handbook, Line Chart, and Matrix methods). Some problems encountered with HEP Form 3-1101 are probably related to study constraints that we imposed upon participants for statistical reasons.

Considering all attributes tested or examined, we believe the Matrix Method is the most useful method we tested for habitat evaluation in water development programs. Matrix estimates were little affected by season or experience of participants. Although Matrix scoring may require a bit more time in the field, it takes equal or less time in office transformation than the other methods. Matrix estimates of measured characteristics were more accurate than those from Line Charts.

Recommendations

1. Biologists performing non-monetary evaluations of habitat quality should be provided with written, standardized criteria, before the field evaluations begin. The criteria should be carefully selected and based on the best biological information available.
2. Criteria should be explicit, and should emphasize quantifiable vegetative characteristics; they should be supplemented by definitions in an accompanying glossary. Relative terms such as "common" should be avoided. Based on our field contact with test participants and scrutiny of test data, brief on-site reviews for participants, including plant identification, should be provided.
3. Criteria and field estimates should be displayed in a format that enhances evaluation of each site independently. The Matrix Method is an example of such a format.

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Evaluation of Wildlife Habitat Inventories

Preliminary Evaluation of a National Wildlife and Fish Data Base

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Introduction

The Forest and Rangelands Renewable Resources Planning Act of 1974 (P. L. 93–378) requires that the Forest Service make and deliver to Congress in 1980 a national assessment of all the renewable resources occurring on the nation's 1.6 billion acres (0.65 billion ha) of forest and rangelands, including wildlife and fish. The Act required that the following aspects of the wildlife and fish resource be addressed in the assessment:

- future needs for wildlife and fish;
- the future availability of those resources to meet identified needs, assuming that present trends continue;
- the economic, social and other implications of failure to meet those needs;
- actions that could be taken so the identified needs could be met more completely; and
- the costs of those actions

A more complete description of the requirements of the law and of the rationale that led to the development of the data base in its present form are provided by Schweitzer et al. (1978).

This paper describes progress in evaluating national wildlife and fish data compiled on (1) future demands (needs), (2) future supplies (availability), (3) the habitat relationships of over 2,500 species and major subspecies of vertebrates and 530 invertebrates that inhabit the nation's forest and rangeland, and (4) strategies to ensure a desirable future for the resource. Data has been compiled by the USDA Forest Service in cooperation with state and other federal agencies on the resident and common migrant wildlife and fish species found in each of the states, territories and possessions. We are evaluating the completeness and validity of this information.

Data needed to support a national assessment either did not exist or had not been compiled prior to the 1980 assessment. For example, the need for and the availability of the wildlife and fish resource was not available for very many species. Comprehensive lists of species were not available for resident and common migrant vertebrate species; consistent definition of wildlife and fish habitat were unavailable; the amount and distribution of habitat was unknown. Since there are no wildlife and fish habitat inventories available at the national level, we looked for surrogates and found some information for rangeland and commercial forestland: the Forest Service timber and range surveys. Therefore, our effort to compile data for the national assessment involved developing comprehensive species lists and defining wildlife and fish habitats for these species using surrogates such as timber size class and range condition class. Existing quantities of these surrogate habitats can be used to assess the impact of alternative land management programs on potential wildlife and fish habitat.

The plan for acquiring the information needed for the 1980 Wildlife and Fish Assessment required input from biologists in the Forest Service and other federal and state agencies. Following an interagency review, the plan was implemented in March 1977 (Schweitzer and Cushwa 1978). Information collection for the 1980 assessment had to be completed in two years. The collection and editing of data will be completed in May 1979; the assessment report will be submitted to Congress in January 1980.

Data on Demand and Supply

Available information is very meager on supply and demand for wildlife and fish. The individual state wildlife and fish agencies are the most comprehensive source of data on the need for and availability of the wildlife and fish resource. Therefore, each state, territory, and possession was asked to estimate use and population trends for individual species or groups of species from the mid-1950s to the mid-1980s.

Table 1. The number of species and major subspecies for which demand and supply data area available, by section and by state.

Section[b]	Section		State	
	Demand	Supply	Demand	Supply
Northeast	223	245	2–150[a]	3–167[a]
North Central	126	232	5–30	5–149
Southeast	56	204	13–31	22–156
South Central	117	695	5–100[a]	5–676
Rocky Mountains	154	201	21–66	22–122
Pacific Coast	41	160	19–26	45–134
Alaska	36	59	36	59
Caribbean islands	2	88	2[a]	22–76
Pacific islands	52	105	52	105
United States, territories and possessions[c]	440	1,184	2–150	3–676

[a]Excludes incomplete data from one state.
[b]The states included in each section are identified in Figure 1.
[c]National summary is not a sum of individual sections because of repetition of species between sections.

Information on either (1) relative trends in animal populations, harvests, or users for a 20-year period including the mid-1970s, or (2) number harvested or in the statewide population in the mid-1970s, or (3) the number of consumptive users in the mid-1970s indicate data are available from at least one state on trends in demand for 150 species and on population trends for 676 species (Table 1). Nationally, some information was available on the demand for approximately 400 species and supply of 1,200 species.

The most comprehensive information available is for animals for which states sell licenses, however; the amount of information varies widely by groupings of species. The following is an example of supply–demand information available for big game species (includes only species and subspecies with supply and demand data from at least 10 states):

Common name	States with data occurrence	States with data demand	States with data supply
Antelope	18	14	16
Bighorn sheep	14	9	12
Black bear	34	24	28
Elk	18	15	17
Moose	14	10	11
Mountain goat	10	8	9
Mountain lion	17	10	16
Mule deer	20	14	18
White-tailed deer	47	40	43

The most extensive information is available for white-tailed deer. Useable comparisons between demand and supply were available in 83 percent of the states the species inhabits. While the above suggests the degree of completeness of the data, it says nothing about the accuracy of the information. In general, there are no independent sources of data that would permit an accuracy check.

Data on the supply and demand for nongame species were meager. The data available concerning nonconsumptive users, including those developed through general literature reviews and special studies, are grossly incomplete and cannot be aggregated. Little can be said quantitatively about trends in such uses except that use increased in the past and probably will continue to increase in the future. Such information is inadequate to meet the requirements of the Resources Planning Act.

A serious limitation on conducting a national assessment is the unavailability of more complete and meaningful data on demand and supply of the wildlife and fish resource, even allowing for our possible shortcomings in compiling data that are available. Deficiencies in demand and supply data result from some combination of shortages in state-level funding and personnel, the difficulties in monitoring the huge number of species, and a historic lack of emphasis on such data to define and justify future management program alternatives.

Data on Species-Habitat Relationships

The compilation of information for the assessment (including that supplied by the states) was carried out by numerous Forest Service wildlife and fisheries biologists across the nation, often with the assistance of other federal, state, and university biologists (Schweitzer and Cushwa 1978). They followed standardized instructions in filling out computer-coded data forms.[1] In spite of attempts to ensure uniformity through the use of a detailed plan, substantial variations occurred in the interpretation of instructions and in the efforts put forth to develop the data.

This section discusses the assessment data concerning species–habitat relationships in respect to its apparent completeness, agreement with other information sources and internal consistency. To the extent that it exhibits incompleteness, disagreements with authorities, or unexplainable variations, there may be errors; and there certainly is a need for more detailed analysis and evaluation.

Land and Water Base Stratification

Political boundaries defined by states, territories, and possessions provided the initial stratification of the nation. Each of these political units was then stratified into forest types (defined by existing vegetation) and range types (defined by potential vegetation). In the contiguous United States, then, species–habitat relationships are defined by forest and range types (Garrison et al. 1977) within states.

Differences between the forest and range types represented in our data base and the complete list of types reported in the 1980 assessment of the forest and rangeland base are a current shortcoming (Table 2). For the purposes of the current assessment, these shortcomings will be considered corrected when a minimum of 95 percent of each state's forest and rangeland acreage and 99 percent of a section's acreage are accounted for. Only the Pacific Coast section now meets both criteria. The South Central and Rocky Mountain sections meet the section criterion but not the state criterion. In the Northeast section the Elm–Ash–

Table 2. Number of forest types and proportions of the forest and rangeland base omitted from Assessment data, in the 48 contiguous states, by section.

Section	Total acreage (millions) of forest and rangeland[a]	Numbers of forest types within states omitted	Percentage of total acreage of forest and rangeland base omitted
Northeast	84.5 (34.2 ha)	9	22.
North Central	82.8 (33.5 ha)	7	2.
Southeast	93.2 (37.7 ha)	5	5.
South Central	230.1 (93.2 ha)	4	1.
Rocky Mountain	546.3 (221.2 ha)	10	0.4
Pacific Coast	166.8 (67.6 ha)	2	0.05

[a]USDA 1977.

[1]More complete descriptions of the data coding instructions and standard tabular displays of information will be provided by Hoekstra et al. (in process).

Cottonwood forest type was omitted in 6 of 11 states having this type; omitting this single type led to ignoring 13 percent of the total acreage in one state. When all types that were omitted are counted, 44 percent of one state's forest and rangeland acreage were left out (3 types). In contrast, there are four states in the Northeast section with representation of wildlife and fish in all types.

Species Lists

A national species list was prepared from the individual state species lists. The distribution across sections by categories of species is shown in Figure 1. To evaluate the completeness of this list, comparisons were made to lists published by taxonomic authorities (Table 3).

The national species list ranges from 78 to 94 percent concurrence with the lists of the authorities. (Only freshwater and anadromous fish were used in the American Fisheries Society comparison). The most frequent deficiencies in the national species list occurred for species with a relatively restricted distribution, marine mammals, and species that were not residents or common migrants. The assessment list also contains additional entries for subspecies in threatened or endangered status, species in the Caribbean and Pacific Islands, hybrid fish species, foreign game introductions and feral species.

The assessment species lists for individual sections differ considerably, because of natural variation in the occurrence of species and because of incomplete information. The number of vertebrate species reported differ by less than 5 percent for two of the sections where our data are most complete, the Rocky Mountain section and the Pacific Coast section. A large difference between the number of reptiles occurring in the two sections is the only major inconsistency (Figure 1).

A rough feeling for the completeness of statewide species lists can be gained by comparing lists from adjacent states and contrasting them to the numbers of species reported within that section. The range in the number of species listed are shown in Table 4. In general, a complete state species list in the continental United States includes between 500 and 700 entries. But even state lists with this number of entries may still be incomplete in one or more categories of vertebrates.

Table 3. Comparison of the species contained in the Assessment data base to those cited by authorities for each category of vertebrate species.

Category of vertebrate species	Species cited by authority	Species in assessment	Species common to both	Species unique to authority	Species unique to national assessment
Amphibian[a]	176	177	166	10	11
Bird[b]	858	978	761	97	271
Fish[c]	701	696	652	49	44
Mammal[d]	402	430	366	36	64
Reptile[a]	265	310	247	18	63
Total	2,402	2,591	2,192	210	453

[a]Dowling 1975.
[b]American Ornithologists Union 1957.
[c]American Fisheries Society 1970.
[d]Jones et al. 1975.

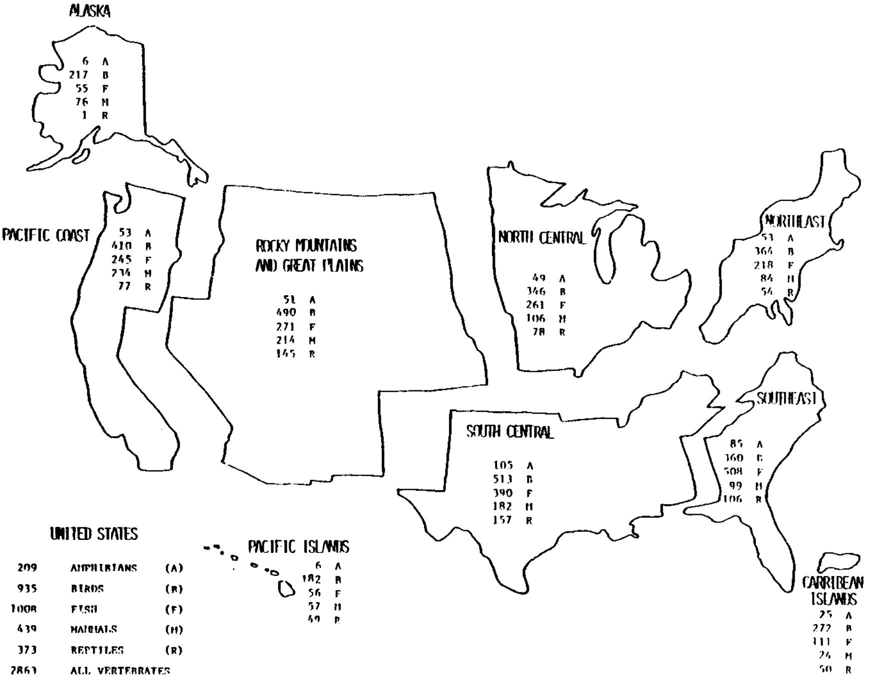

Figure 1. Distribution and number of resident and common migrant vertebrate species in the United States, by section.

Table 4. The total number of species by section and the range in total number of species for states of the section providing species habitat information.

Section	Section total	State total (range)
Northeast	779	174—725
North Central	852	90—592
Southeast	1,218	523—699[a]
South Central	1,529	564—915
Rocky Mountains	1,173	169—610
Pacific Coast	1,055	650—801
Alaska	388	388
Caribbean islands	507	208—482
Pacific islands	351	35—160
United States, territories and possessions	3,292	35—915

[a]This does not include one state where there is no information.

At this time data are still being gathered for states in several sections; therefore, the numbers reported in Figure 1, and Tables 4 and 5 are approximate and differ from data in Table 3. Where state data are obviously deficient, they are being reviewed and completed by recognized local authorities.

Information in the assessment indicates that, of the approximately 3,000 species listed as resident or common migrant vertebrates, 85 percent occur in forest types, 61 percent in range types and 49 percent are found in both (Table 5). Birds, mammals, and reptiles are more evenly distributed between forest and range types than the other verbebrates. The number of fish species in forest types is considerably greater than in range types. At the present time there is no known list of species for any or all vertebrate categories in forest or range types with which we can compare the assessment listing on an ecological basis. We have reason to believe we are reasonably correct because of the obvious differences in structural diversity between plant communities in the forest and range types and the numerous studies on the close relationship between diversity of habitat and animal species (MacArthur 1965).

Species Lists Within Types

The assessment listings of birds within each of the forest and range types in Maryland, Colorado, and Oregon were examined by specialists in the Migratory Bird and Habitat Laboratory, U.S. Fish and Wildlife Service. Few major discrepancies were identified. There were 25 or fewer changes in the species relationship to forest and range types recommended by these specialists in each of 17 types, more than 50 changes recommended in each of two types, and no changes recommended for one type.

Comparison of the data compiled in different sections for the same types illustrates the fact that large discrepancies exist within the data base at this level of generalization. Consider the extensive Ponderosa Pine type. The species list of vertebrates for the Pacific Coast contains 56 percent as many species as that for Ponderosa Pine in the Rocky Mountains section. Amphibians, mammals, and reptiles are represented in comparable numbers, but there are large differences in the numbers of birds and fish. Our experience in examining the national data base suggests that the low numbers of birds and fish listed in the Pacific Coast Pon-

Table 5. Numbers of resident and common migrant vertebrate species and selected subspecies found in forest and range types in the United States, by category.

Category of vertebrate species	Total species by category	Species occurring in forest types	Species occurring in range types	Species occurring in both forest and range types
Amphibian	173	154	112	93
Bird	942	829	737	624
Fish	1,193	1,029	435	334
Mammal	417	332	344	259
Reptile	304	236	228	160
All vertebrates	3,029	2,580	1,856	1,470

derosa Pine type do not reflect real differences in species occurrence: most of these differences are due to inadequacies in the procedures followed in compiling information.

Three widely separated states in the Rocky Mountain section and the three states making up the Pacific Coast section were examined to illustrate the next lower level of generalization of the data. Comparison of species listed in common for Ponderosa Pine in states of the Rocky Mountain section indicate that fish are most consistently reported vertebrates for Montana, Colorado, and New Mexico (Table 6). In contrast, the numerical comparison for Washington, Oregon and California demonstrates more consistent occurrence for all vertebrate categories, except amphibians, than for states in the Rocky Mountain states in Ponderosa Pine. We are currently unable to judge whether the difference in occurrence for each vertebrate category is the result of natural variation or our procedures.

Defining Species–Habitat Relationships

Wildlife and fish species habitat relationships in vegetation types were defined by relating species primarily to aquatic, terrestrial, and mixed terrestrial–aquatic environments, and secondarily to water temperature class (aquatic), timber size class (terrestrial) or specialized habitats (all environments). In general, it appears that if species are found in a given vegetation type that occurs in several states, and if their occurrence is properly compiled, they are also consistently placed in the same broad environmental setting or type of habitat. For example, in the Ponderosa Pine type, comparisons between groups of states show that birds, mammals and reptiles are most consistently related to terrestrial environments (Table 7). Obviously, fish are placed in aquatic habitats, and amphibians are consistently related to mixed habitats. The low numbers of entries for birds, mammals and reptiles in mixed terrestrial-aquatic environments indicate the biologists who compiled the assessment data were not consistent.

Species consistently related to the broad environmental setting or types of habitat can be further examined to see if their secondary relationship to habitat class were consistently specified. Low levels of consistency are evident in identifying the relative importance of timber size class or water temperature class for vertebrate species. Between 16 and 44 percent of the species were consistently related to particular habitat classes in the Pacific Coast states. Success was lower in widely separated states in the Rocky Mountain section; it ranged from 8 to 22 percent.

To further explore the relationship of species habitat classes, in this case timber size class, the bird species in Maryland, Colorado and Oregon were again examined by Fish and Wildlife Service biologists. In the assessment data base very few species in Colorado or Maryland had been listed as being broadly distributed across two or more timber size classes; in Oregon 15 percent of the birds had been so categorized. Fish and Wildlife Service biologists indicated that 39, 34, and 54 percent, respectively, are in fact broadly distributed in respect to timber size classes in these states. In Maryland, the assessment data indicated 91 percent of the bird species were associated with only one or two timber size classes, while Fish and Wildlife Service information showed only 28 percent should be classified in this manner. The assessment information for bird species associated with a

Table 6. Number of species reported to occur in the Rocky Mountain and Pacific Coast Section Ponderosa Pine type and the species consistently listed among three states.

Category of vertebrate species	Rocky Mountain Ponderosa Pine Type					Pacific Coast Ponderosa Pine Type				
	Total species occurrence in section	Total species occurrence in type	Species listed in common among states			Total species occurrence in section	Total species occurrence in type	Species listed in common among states		
			MT	CO	NM			CA	OR	WA
Amphibian	51	20	3	4	12	53	26	23	11	9
Bird	490	402	76	169	222	410	189	128	125	122
Fish	271	140	28	20	27	245	79	55	57	45
Mammal	214	135	32	59	71	234	112	86	74	70
Reptile	145	62	5	5	41	77	22	21	13	10
Total	1,171	759	144	257	373	1,019	428	313	280	256

Table 7. The numbers of species listed in common in selected states, and consistently related to type of habitat and habitat class in the Rocky Mountain (RM)[a] and Pacific Coast (PC)[b] sections.

Category of vertebrate species	Species listed in common to three states		Species consistently related to type of habitat						Species consistently related to habitat class	
			Terrestrial		Aquatic		Mixed			
	RM	PC	RM	PC	RM	PC	RM	PC	RM	PC
Amphibian	1	6	0	1	0	0	0	5	0	0
Bird	43	63	38	57	0	0	1	2	3	19
Fish	4	25	0	0	4	25	0	0	4	4
Mammal	19	47	9	41	0	0	0	2	2	18
Reptile	2	9	2	8	0	0	0	1	0	0
Total	69	150	49	107	4	25	1	10	9	41

[a]Montana, Colorado, New Mexico.
[b]Washington, Oregon, California.

single timber size class was consistent for Colorado (64 percent) and Oregon (63 percent) but differed markedly from the Fish and Wildlife Service information which classified 18 and 12 percent of the species by single timber size classes.

The importance of correctly identifying the timber size classes where birds are found lies in the potential use of timber size class as a surrogate for wildlife habitat. We made the assumption that population trends (of species associated with timber classes) are related to changes in the acreage of timber size classes. To evaluate this assumption, data for Maryland on forest acreages by timber size classes (Ferguson 1967, Powell and Bowers 1978) were compared to bird population trend data (from the Breeding Bird Survey of the Fish and Wildlife Service). Changes in acreage of timber size classes are for commercial forest lands; we have no comparable acreage estimates on noncommercial forest land. We have assumed that timber size class acreage on commercial forest land is a good measure for all forest land.

Red-bellied woodpeckers are commonly associated with large acreages of sawtimber trees in forested areas. Between 1964 and 1976, there was a 21 percent decrease in the acreage of sawtimber. During the same period the statewide population of this species decreased 21 percent, from an average of 7 birds per Breeding Bird Survey route to approximately 5.5. Populations of several other woodpecker species commonly associated with mature forests also decreased during this period.

There was a decrease of 12 percent in pole-sized timber stands in the period. Brown thrasher and downy woodpecker populations decreased 30 and 14 percent respectively, during the period.

The seedling-sapling timber size class had a major (47 percent) increase in acreage between 1964 and 1977. Changes in the sizes of bird populations were not closely related to change in the acreage of seedlings- and saplings-sized timber. White-eyed vireo increased and yellow-breasted chats and prairie warblers decreased during the sample period.

Summary and Conclusions

A national wildlife and fish data base was developed by the Forest Service in two years to support the 1980 assessment required by the Forest and Rangeland Renewable Resources Planning Act. Information on the demand and supply of wildlife and fish and their habitat relationships is included. The data are based on existing information. A thorough evaluation of the assumptions used to compile and interpret the national assessment information is necessary if future assessments are to be improved and if the data are to be useful for other purposes.

Information identified as inadequate or incorrect in this data base is being revised and updated. In those areas where the data are the weakest, we have contracted with recognized authorities to revise the information. We expect to have a reasonably correct and consistent set of data by mid-summer, 1979.

The requirements of the Resources Planning Act are only partially met by the current data base. The comprehensive summation of animal habitat requirements is inadequate to incorporate the needs of all vertebrates in all land areas of the United States into the planning process. A comprehensive classification and quantitative inventory of wildlife and fish habitat does not exist. Surrogates used need to be evaluated. Consequently, we are uncertain about the impact of alternative land management practices on wildlife and fish habitat or populations. The selection of hierarchical components used in integrating natural and political systems in large part determine the internal consistency of wide-area data bases. Faunal diversity should be one component considered in defining the classification of land and water.

The 1980 National Assessment of Wildlife and Fish is a benchmark in the process of integrating this resource in the planning process for meeting man's total needs. The 1975 assessment of wildlife and fish written from existing and published information was the first national assessment. The 1980 assessment is the first attempt to make an assessment using a national data base.

Recommendations

Demand (need) and supply (availability) information for the wildlife and fish resource is inadequate to make a national assessment. Cooperative state and federal efforts should be expanded to acquire estimates of demand and supply for more species of wildlife and fish. Special consideration needs to be given to nongame wildlife and fish since interest has increased dramatically, but where demand and supply data are the weakest.

A national standard for the classification and quantitative inventory of wildlife and fish habitat does not exist. Current state and federal research efforts need to be coordinated in defining a comprehensive and consistent set of parameters for wildlife and fish habitat. In addition, joint state and federal effort is required to have a comprehensive nationwide inventory of wildlife and fish habitat to allow evaluation of tradeoffs or interactions within the wildlife and fish resource and between it and other natural resources.

Existing land classifications are unable to link wildlife and fish habitat requirements to other natural resources. A joint state and federal effort is needed to develop an integrated land classification which functionally links wildlife and fish habitat requirements to other natural resource components.

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A Comparison of Three Systems for Evaluating Forest Wildlife Habitat

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Realizing the need for better communication among researchers working on habitat evaluation procedures, the United States Fish and Wildlife Service sponsored a national symposium in 1977 dealing with classification, inventory, and analysis of fish and wildlife habitat. This meeting provided an opportunity for individuals from federal, state, and private natural resource agencies to make progress toward establishing a common direction and framework for accurate assessment of the value of fish and wildlife habitats. Much of the habitat research conducted since this symposium (Bailey 1978, Shugart et al. 1978, Tipton and Lackey 1978) suggests that researchers are making an effort to coordinate the development of habitat evaluation systems. However, no comparisons of different systems have been made to determine if they provide similar habitat ratings when the same data base is used in each system.

In this study we chose, for comparison, three habitat evaluation systems. One of these systems, DYNAST (Boyce 1977, 1978, personal communication), is being developed by the United States Forest Service; another system under development is the Habitat Evaluation Procedures (HEP) by the United States Fish and Wildlife Service (Flood et al. 1977); the third system is called an Information System for Wildlife Habitat Evaluation (Williamson et al. 1978) which is currently being developed at the Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University. Our objective was to compare forest habitat suitability ratings, as determined by three different habitat evaluation systems for white-tailed deer (*Odocoileus virginianus*), wild turkey (*Meleagris gallopavo*), and gray squirrel (*Sciurus carolinensis*). Habitat ratings were calculated for the study area under current forest stand conditions, a timber management practice, and a wilderness condition.

Study Area

The 4,759 acre (1,927 ha) study area may be broadly classified as Appalachian mixed-hardwood forest. It is located on Peters Mountain in the James River Ranger District, George Washington National Forest, Allegheny County, Virginia. The major forest cover types and percent of the total area represented by each are Chestnut Oak (34.6), White Oak–Red Oak–Hickory (29.2), Bear Oak–Pitch Pine (12.4), Yellow Poplar–White Oak–Northern Red Oak (11.0), and Scarlet Oak (7.9). There are 132 forest stands in the study area, with an average stand size of 36.4 ± 23.3 acres (14.6 ± 9.4 ha). The White Oak–Red Oak–Hickory cover type is typical of the stands at the lower elevations (1800–2000 feet, 549–610 m), whereas stands typical of drier sites and steeper slopes such as Chestnut Oak and Bear Oak–Pitch Pine are dominant at higher elevations (2500–3000 feet, 762–1006 m).

The average age of dominant and co-dominant trees and the average basal area on medium quality sites (site index 60 ± 10) is approximately 90 years and 77 sq. ft/acre (17.6 m^2/ha). Similar data for low quality sites (site index 50 ± 10) is 90 years and 69 sq. ft/acre (15.7 m^2/ha).

Methods

Data used in each of the three systems described were obtained from the forest inventory of the study area provided by the United States Forest Service, in both map (topographic overlay) form and tabular (computer output) form.

Information System (VPI&SU)

This system (Williamson et al. 1978) is being developed at Virginia Polytechnic Institute and State University to evaluate wildlife habitat potential of forested areas. A time–event simulation is used to predict vegetational characteristics as would occur under different timber harvesting systems and a wilderness condition. Using the system, information on the status of wildlife habitat may be determined for the current situation, or at some time in the future.

Major habitat factors such as food, cover, etc. for each wilderness species are defined and ranked in relative importance on a scale from one (least) to 10 (most) important. Levels, or intensities, of individual factors such as hard mast production were stratified into a maximum of 10 categories and assigned values ranging from one to 10. Importance values were derived from literature sources and expert opinion. Both intensity levels and the relative importance value for each habitat factor were assigned in a linear fashion. Thus, a qualitative habitat suitability rating for any given area can be simply expressed in equation form:

$$V = \sum_{i=1}^{n} b_i X_i,$$

where

V = habitat value,
b_i = relative importance of the i^{th} habitat factor,
X_i = relative intensity of the i^{th} habitat factor,
$i = 1, 2, 3, \ldots, n$.

Habitat values for deer, turkey, and squirrel were calculated using forest stand condition data from Table 1, stand condition maps, and wildlife data from stand prescription summaries. Values were determined for the current vegetative conditions on the study area, for the habitat conditions which would result from a specified timber management practice, and for a stabilized successional stage corresponding to a wilderness habitat condition. The rotation ages and percent of timber harvested in the timber management mode were the same as those used in the DYNAST program described later in this section of the paper.

Habitat ratings for each wildlife species can be portrayed graphically in the form of computer-generated maps, using the CMSII mapping program (Federation of Rocky Mountain States 1977) which is an integral part of our habitat evaluation system. However, for this study, the map output is not presented.

Descriptions of habitat factors and data on relative intensity levels and relative importance values for deer, turkey, and squirrel used in this system were as follows:

White-tailed Deer:

Hard mast. Pounds/acre dry weight to meet daily energy requirements of an adult female deer during a 76-day fall period at a density of 1 deer/35 acres.[1] (10 acres = 2), (20 = 4), (30 = 6), (40 = 8), (50 = 10)[2] *Multiplier:* 9

Forage. Pounds/acre dry weight to meet daily requirements of an adult female deer for 365 days at a density of 1 deer/35 acres (5 pounds = 2), (10 = 3), (15 = 5), (20 = 7), (25 = 8), (30 = 10) *Multiplier:* 9

Distance to permanent water. Measured from the center of each forest stand. Abundant (within 0.5 mile = 9); Available (0.5–0.75 mile = 7); Infrequent (approximately 1 mile = 4); Scarce (> 1.5 miles = 2) *Multiplier:* 3

Cover. Percent of each forest stand covered by dense coniferous or evergreen cover Scarce (< 20 percent = 2); Moderate (20–60 = 6); Abundant (> 60 = 9) *Multiplier:* 7

Wild Turkey:

Hard mast. Same range of importance values as for white-tailed deer, based on calculations which indicate that mast production corresponding to these values will be adequate to meet the daily energy requirements of both deer and turkey at reasonable densities (1 deer/35 acres and 1 turkey/100 acres) *Multiplier:* 9

Diversity. Number of desirable mast-producing species in mid-and overstory per acre (5 + /acre = 9), (3–5 = 7), (2–3 = 4), (1 = 1) *Multiplier:* 6

Competition. From cattle, hogs, deer, etc. None apparent (9); Light (8); Moderate (4); Heavy (10) *Multiplier:* 5

Distance to permanent water. Same as white-tailed deer. *Multiplier:* 5

Extent of continuous forest. Total acreage of forest canopy, the boundary of which, has no breaks of more than one-half mile in width. (25,000–50,000

[1]Relative Intensity Level (0–10)
[2]Relative Importance Value (0–10)

Table 1. Hardwood stand inventory (in acres) by site classes, habitats, and accessibility for a 4,759 acre (1,927 ha) study area on the James River Ranger District, George Washington National Forest, Allegheny County, Virginia (1978).

Habitat	Medium sites (Site index 60 ± 10)			Low sites (Site index 50 ± 10)			All site and access Classes
	Accessible	Inaccessible	Subtotal	Accessible	Inaccessible	Subtotal	
Seedling	—	—	—	—	—	—	—
Sapling	—	—	—	—	—	—	—
Pole 6-inch[a]	—	103	103	—	—	—	103
Pole 8-inch[b]	90	131	221	180	673	853	1,074
Pole 10-inch[c]	425	674	1,099	41	709	750	1,849
Mature timber[d]	438	1,070	1,508	33	192	225	1,733
Old growth[e]	—	—	—	—	—	—	—
Total	953	1,978	2,931	254	1,574	1,828	4,759

[a]5–6.9 inches (12.7–17.5 cm) for medium and low sites (median diameter).
[b]7–8.9 inches (17.8–22.6 cm) for medium and low sites (median diameter).
[c]9–10.9 inches (22.9–27.7 cm) for medium sites. (median diameter); 9+ inches (22.9 cm) for low sites (median diameter).
[d]11–15.9 inches (27.9–40.4 cm) for medium sites (median diameter); 9+ inches (22.9 cm) for low sites (median diameter).
[e]16 + inches (40.6+cm) for medium sites (median diameter).

acres = 9), (10,000–25,000 = 7), (5,000–10,000 = 5), (1,000–5,000 = 1) *Multiplier:* 7

Gray Squirrel:

Hard mast. Same range of importance values as described for deer and turkey. Mast production is adequate to meet the daily energy requirements of deer, turkey, and squirrel at reasonable densities (1 deer/35 acres; 1 turkey/100 acres, and 1 squirrel/2 acres) *Multiplier:* 9

Diversity. Same range of importance values as described for deer and turkey. *Multiplier:* 6

Competition. From cattle, hogs, deer, etc. None apparent (10); Light (8); Moderate (5); Heavy (1) *Multiplier:* 1

Distance to permanent water. Water within 100 yards (9); water over 100 yards (0) *Multiplier:* 1

Den trees. Number/acre (> 5/acre = 10), (4–5 = 8), (2–3 = 5), (1 = 2), (< 1 = 1) *Multiplier:* 8

Data from the following sources were used to develop the preceding weighted habitat parameters: for deer—Moen 1973, Whelan 1974, Giles 1978, United States Forest Service 1971, Flood et al. 1977, Zeedyk 1969, and Halls 1978; for turkey—Holbrook and Lewis 1967, Hewitt 1967, Bailey and Rinell 1968, Mosby 1949, Speake et al. 1975, Sanderson and Schultz 1973, United States Forest Service 1971, Lewis 1973; and for squirrel—Montgomery et al. 1975, Sanderson et al. 1975, Short 1976, Doebel and McGinnes 1974, Cordes and Barkalow 1972, Barkalow et al. 1970, and United States Forest Service 1971.

Habitat Evaluation Criteria (USFWS)

The Office of Biological Services within the United States Fish and Wildlife Service is developing and refining procedures for quantifying impacts of habitat alteration and land use changes on fish and wildlife resources. The overall evaluation process is a two-stage approach where species-oriented data on habitat suitability are acquired and then utilized in an evaluation procedure (Flood et al. 1977) to estimate the impact of land and water alterations on fish and wildlife. The species-oriented data bases are being compiled into Habitat Evaluation Criteria Handbooks, following the ecosystem approach developed by Bailey (1978), and used to provide habitat suitability indices (HSI) for selected wildlife species in a habitat type (e.g., upland hardwood, bottomland hardwood). The derivation of indices is based on data obtained from the literature and expert opinion. These data are used to construct production curves which show a range of species responses (optimum to least desirable) to certain habitat characteristics. Data from the production curves are utilized in life requisite equations, as described in the handbook, and a computer-generated HSI for each species on a given area is calculated. The HSI for any species is the lowest life requisite equation, based on the limiting factor concept.

For this study we used information from the Terrestrial Habitat Evaluation Criteria Handbook, Ecoregion 2211, Appalachians (Review Copy, July 1978) to calculate HSIs for white-tailed deer, wild turkey, and gray squirrel. Some of the habitat criteria (factors) used in this system were modified with the intent to improve the estimated HSI for a species. All habitat factors and corresponding suitability weights, ranging from 0–1.0, which were used for calculating HSI's are described in the handbook. Forest stand condition data from Table 1 were used, together with stand condition maps and wildlife data from stand prescription summaries, to evaluate wildlife habitat for current forest conditions. Habitat ratings for the timber and wilderness management modes were calculated on the basis of predicted habitat conditions using the time-event simulation program of the Information System (VPI&SU).

DYNAST System (USFS)

The DYNAST system, an acronym for "Dynamically Analytic Silviculture Technique," is designed for managing forests by actions harmonized to produce multiple benefits (Boyce 1977, 1978).

Variations in biotic characteristics of forest communities suggest that each community could provide a different combination of benefits. As stated by Boyce (1977, 1978), benefits available from a given forest depend primarily on the proportion and physical distribution of habitats, different forest communities dominated by particular stand age classes.

Since the system is based on the relationship between forest benefits and habitats, a practical classification of habitats is needed for each area being studied. The classification for Appalachian hardwood forest habitats is as follows: seedling, sapling, three stages of pole growth, mature timber, and old-growth. The DYNAST programs used in this study (DYNAST-OB, Optimum Benefit) projects the distribution of the seven forest habitats as a result of different harvest practices called management modes. A mode consists of (1) the fraction of forest to be rotated through the old-growth stage, (2) harvest ages for old-growth and mature timber, and (3) the size of openings created by timber removal. The distribution of age classes in forest habitats is related to the habitat requirements of forest wildlife species by algorithms which show the relationship between proportions of different habitats and their relative contribution toward meeting species requirements, scaled from 0–1.0. All algorithms were developed using information from literature sources, particularly symposia proceedings, and expert opinion.

Output from the program is a graphic display showing the relative benefit to timber, wildlife, sediment flow, and landscape esthetics. Relative benefits for each of these forest resources is shown for a wilderness (no silvicultural practices) mode, a timber management mode, and an optimum benefit mode. The optimum benefit mode could be called the "compromise mode" since the objective in this mode is to cluster timber, wildlife, and other forest resources near the top of the relative benefit scale.

The forest tree inventory for the study area, which shows the current stand conditions by site classes, habitats, and accessibility is presented in Table 1.

The rotation ages assigned to medium and low quality sites, classified according to accessibility, are shown in Table 2 for the timber and optimum benefit management modes of the program. The size of openings created by harvesting of timber was 25 acres (10.1 ha).

Data from Table 1, together with information on rotation ages and percent of timber harvested were used in conjunction with wildlife algorithms developed for the George Washington National Forest (Boyce 1977, 1978, personal communication) to calculate the relative benefit values of study area habitats for deer, turkey, and squirrel under current stand conditions, and timber and wilderness management modes.

Results and Discussion

Ideally, if each habitat evaluation system had been developed independently of the other and each was providing an accurate evaluation, then each system should give nearly the same habitat rating within any management mode for a particular species. If the systems were not developed independently, the probability of

Table 2. Rotation ages assigned to medium and low quality sites.

	Accessible stands		Inaccessible stands	
	Timber mode	Optimum benefit	Timber mode	Optimum benefit
Medium sites				
(site index 60 ± 10)				
Rotation age (years)	120(300)	100(300)	120(300)	100(300)
Percent harvested	95 (5)[a]	55 (45)	95 (5)	55 (45)
Low sites				
(site index 50 ± 10)				
Rotation age (years)	100(190)	100	100(190)	No harvest
Percent harvested	85 (15)	100	85 (15)	No harvest

[a]Values in parentheses on the percent harvested row indicate the percent of stands allowed to continue into old-growth habitat following the initial harvest, e.g. 5 percent harvested at 300 years.

obtaining similar ratings should be increased to the extent that similar habitat factors and similar weighted values for these factors were utilized in each system.

Habitat ratings, determined by the three different evaluation systems, showed considerable variation for deer, turkey, and squirrel both within and among forest management modes (Figures 1, 2, and 3). At best, the minimum ranges for all ratings within any management mode were 38–67 percent and 15–44 percent (Figures 2 and 3). These apparent differences among systems within any mode should not be unexpected, as mentioned earlier, since some of the habitat factors and their importance values for each species differed among systems.

Considering all species and evaluation systems, in six out of nine comparisons of habitat ratings within a mode, the Information System (VPI & SU) and Habitat Evaluation Criteria (USFWS) showed closer agreement, however, the range of values in some cases was still relatively large, e.g., 36–67, 46–67 (Figure 2) and 32–53 (Figure 3). The closer agreement in ratings between the VPI & SU and USFWS systems, compared to DYNAST, was apparently due to the similarity in habitat factors used in these two systems.

Habitat ratings determined by DYNAST, excluding the Optimum Benefit program, were lower for all species within any mode, except for turkey in the current mode (Figure 2) and squirrel in the wilderness mode (Figure 3). In general, the wide variation in DYNAST values can be explained on the basis of importance assigned to the few habitat/wildlife algorithms included in this system for each species. For instance, the importance assigned to hard mast for turkey is reflected

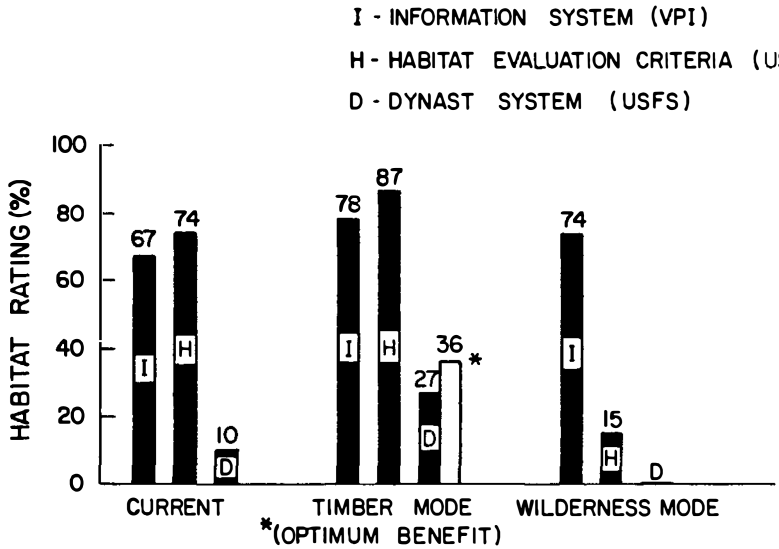

Figure 1. Habitat suitability ratings for white-tailed deer in a mixed hardwood forest of southwest Virginia, as determined by three different habitat evaluation systems under current stand conditions and projected management practices. (Optimum benefit is the management practice which tends to cluster timber, wildlife, and other forest resources near the top of the DYNAST relative benefit scale.)

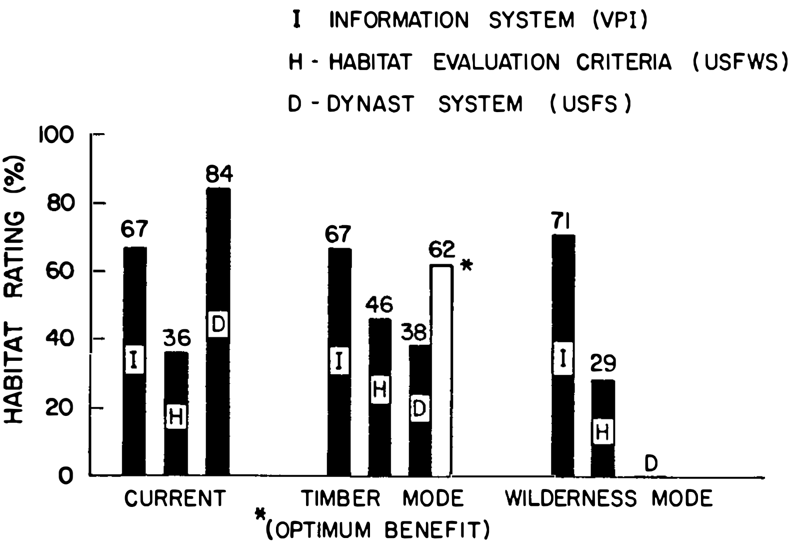

Figure 2. Habitat suitability ratings for wild turkey in a mixed-hardwood forest of southwest Virginia, as determined by three different habitat evaluation systems under current stand conditions and projected management practices. (Optimum benefit is the management practice which tends to cluster timber, wildlife, and other forest resources near the top of the DYNAST relative benefit scale.)

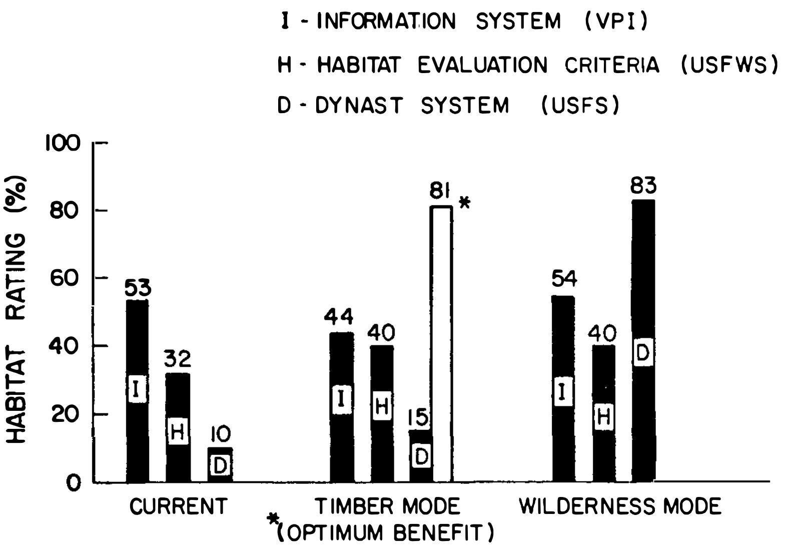

Figure 3. Habitat suitability ratings for gray squirrel in a mixed-hardwood forest of southwest Virginia, as determined by three different habitat evaluation systems under current stand conditions and projected management practices. (Optimum benefit is the management practice which tends to cluster timber, wildlife, and other forest resources near the top of the DYNAST relative benefit scale.)

in the high value of 84 under current conditions (Figure 2), and percent of old-growth habitat for den trees is very important to squirrels as shown in the wilderness mode of Figure 3. Likewise, the zero values under the wilderness modes of Figure 1 and 2 reflect the importance attached to the amount of seedling habitat and size of openings for deer and size of openings for turkey. These habitat conditions are almost nonexistent in a wilderness condition.

Ratings for DYNAST (Optimum Benefit) under the timber mode increased because the silvicultural practices represented by this program would provide more seedling habitat and openings for deer and turkey and more den trees for squirrel than the timber mode, which places more emphasis on wood production.

A simple test was performed to determine the "sensitivity" of each evaluation system to variations in hard mast production and its effect on turkey habitat ratings in the timber mode. An increase of 20 percent in hard mast had no effect on DYNAST ratings, however, values for the VPI & SU and USFWS systems increased by 12 percent and 58 percent, respectively. The explanation for the lack of response by DYNAST to an increase in hard mast production is that the proportion of mast-producing trees on the study area had exceeded 50 percent of the total area, which is the limit assumed for maximum contribution of hard mast to turkey.

Conclusions

The underlying question which arises from our comparisons of forest habitat evaluation systems is: which system estimates most accurately the potential of a given habitat for meeting the life requirements of particular wildlife species? A partial answer to this question is that the system which incorporates the best available data and is least subjective, relative to the selection and weighting of habitat factors for constructing production functions (Giles 1978), should be the most accurate. However, the question will not be resolved satisfactorily until other systems have been compared and, more importantly, replicated validations made to determine the predictive capability of these evaluation systems.

Recommendations

We should continue to improve interagency communication in our efforts toward improving habitat evaluation systems, emphasizing cooperation in the refinement of wildlife production functions. Whenever possible, algorithms should be developed using bioenergetic information for the construction of species production functions which will best reflect the functional significance of habitat factors to species. Sensitivity tests of algorithms will aid in selecting those habitat factors which appear to be functionally important for each species and necessary to achieve an acceptable level of accuracy for the evaluation.

A concerted effort should be made to compare and validate evaluation systems. Preliminary results from the initial validation should indicate to what extent the habitat factors and/or importance values need modification to provide more biologically meaningful evaluations of current habitat potential.

The following approach is suggested for validating selected systems to be used at the local (e.g., forest ranger district) level: first calculate and map (Williamson et al. 1978) ratings of current habitat potential for common wildlife species on three areas, each with similar vegetative composition, access (roads, trails, etc.)

and proximity to developed areas, but having widely different habitat (forest successional stage) conditions. Each area should be approximately the same size and sufficiently large to encompass the home ranges of most forest-wildlife species, except perhaps for black bear. Next, the habitat ratings would be compared, within and among areas (Whelan 1977), to information on relative abundance (density) of each wildlife species being considered. The system whose habitat ratings consistently correspond more closely to relative abundance values would be the most accurate. Estimates of relative abundance can be obtained either from information on previous research in the study areas or from current studies, using both direct and indirect methods for estimating populations (Overton and Davis 1969, Giles 1978).

Although the information presented has been directed at the local level of wildlife habitat evaluation and validation of systems, regional assessments of wildlife habitat potential could be made using a similar approach. Using more generalized habitat factors, based on Bailey's (1978) levels of habitat classification for a particular ecoregion (Cushwa, personal communication), it may be feasible to develop more broad-based wildlife production functions for regional habitats and use them to estimate habitat potential on a larger scale. Again, it would be necessary to validate such a system by comparing estimates of habitat ratings to data on relative densities of selected species or species groups within an ecoregion. Several different levels of habitat classification could be used in an evaluation to determine what percent of the variation in estimated population densities within an ecoregion can be explained by the number of classification levels used to define the ecoregion.

Agencies involved in developing habitat evaluation systems should support a cooperatively funded project for validation of systems at both local and regional levels. Meaningful results from such a cooperative effort could be available within two years following project initiation.

Acknowledgements

We wish to acknowledge the assistance of the following agencies in this study: The United States Forest Service (George Washington National Forest and Southeastern Forest Experiment Station); United States Fish and Wildlife Service (Office of Biological Services); and the Department of Fisheries and Wildlife Sciences, Virginia Polytechnic Institute and State University. Appreciation is expressed to Stephen Boyce, Jack A. Williams, and Joseph F. Hudick for their advice and assistance in collection and analysis of data. Special thanks are due Greg Koeln, Blair Jones, and Ned Okie for their assistance in the development of the computerized information system.

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Regional Evaluation of Wildlife Habitat Quality Using Rapid Assessment Methodologies[1]

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Introduction

The development of domestic energy and mineral resources is important to every nation and this continued resource development has direct and indirect impacts on wildlife and wildlife habitat. A procedure to rapidly and accurately determine the relative value of land as wildlife habitat is essential if decision makers are to make environmentally responsible decisions concerning suitable locations for development. Such a procedure must compare areas of potential development with other lands in the region so that unique, high quality habitats of special importance can be identified and protected. The rapid assessment methodology presented in this paper can be used to evaluate the quality of wildlife habitat in regionwide areas and will help identify suitable areas for development so that adverse impacts on wildlife resources can be minimized.

The need to rapidly evaluate the quality of wildlife habitat over large areas is evidenced by the pressure to develop coal in the Northern Great Plains, where much of the United States' coal reserves occur. These reserves underlie approximately 2.6 million surface-mineable acres (1.05 million ha) (Anonymous 1975) with a complex of surface and mineral ownerships. The leasing of federal coal reserves in this vast area may be resumed in early 1980. This potentially mineable area varies greatly in habitat quality for wildlife. Some portions of this area are protected by legal mandates because they are habitat for endangered species or migratory birds. Other lands are important agricultural or woodland areas or contain geological features, such as cliff faces and spires that have great aesthetic, recreational, or historical importance.

The Coal Project of the Western Energy and Land Use Team (WELUT), Office of Biological Services, U.S. Fish and Wildlife Service, has developed a process for evaluating regional wildlife habitat quality based on the interpretation of recent aerial photography according to the vegetation composition and structure, land use, and special interest features. Interpretation of aerial photography produces a map of surface features that is digitized and computer manipulated to develop variables which are introduced into regression equations to predict bird species diversity (BSD) values.

Areas having limited habitat diversity and low BSD values are considered potentially suitable for resource development. These lands are further evaluated to identify factors that might exclude them from mining for legal reasons, such as

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endangered species habitats or archaeological sites, or because of other environmental concerns, such as blue ribbon trout streams or cliff faces that serve as raptor nest sites. This evaluation produces a map and/or list of areas suitable (or unsuitable) for coal development from an environmental viewpoint. These preliminary rankings can assist federal, state, and private planners and decision makers in their task of balancing environmental concerns with energy development needs when the rankings are considered with such information as strippable coal reserves, surface and mineral ownerships, and social and economic data. The total process is illustrated in Figure 1.

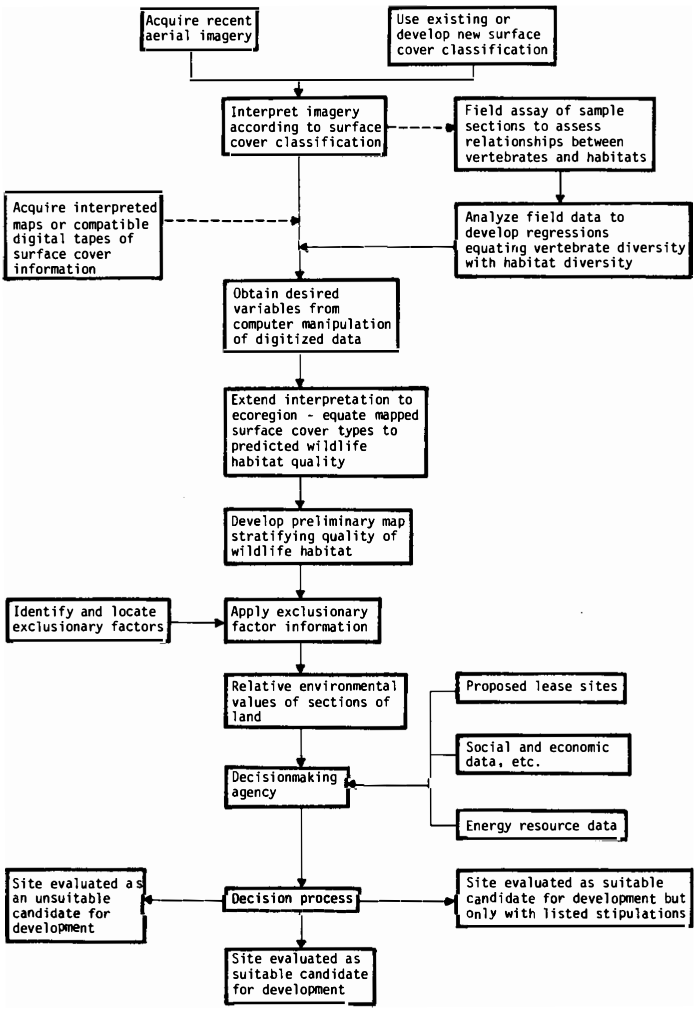

Figure 1. Flow chart depicting procedure for evaluating regional wildlife habitat quality and how this information might be used in the land use planning process.

Our assessment of the quality of wildlife habitat is based on two assumptions: (1) habitat quality is a direct function of habitat diversity for the majority of terrestrial vertebrate species; and (2) characteristics that contribute to the diversity of wildlife habitat such as interspersion of different vegetation or cover types, canopy cover of particular types, vegetative strata present, quantity and quality of edge between vegetation types, presence and distance to water, and unique physical features like cliff faces can be assessed from aerial photography.

There are, in addition to mappable habitat characteristics, special areas which can only be adequately identified and/or verified by ground-truthing. These habitats are often functions of regional geography and animal behavior, such as seasonal wildlife ranges, leks, and critical habitat for threatened or endangered species.

This methodology to assist in identifying suitable areas for resource development was designed to be: (1) objective and capable of being implemented over regional areas using existing or easily acquired information; (2) transferable, with suitable recalibration, to other geographical regions; (3) able to provide data to the decision maker that can be used to determine the relative quality of various habitats to wildlife; and (4) able to integrate information for as many different vertebrate species as possible.

Methods

Ecological Test Area

The Western Energy and Land Use Team has identified five regional ecological test areas in the western United States (Figure 2) where large scale energy developments, especially coal strip mining and oil shale development, are likely to occur. Habitat analysis and methodology development are currently restricted to the Montana/Wyoming Ecological Test Area (M/W ETA). Prototype development of our habitat evaluation procedure occurred in the Hardin NE Quadrangle (1:100,000 scale) in southeastern Montana, the first portion of the M/W ETA for which interpreted aerial photography was available.

The test area in the Hardin NE Quadrangle contains all or parts of 387 legal sections of land in Powder River and Rosebud counties, Montana, within the drainages of the Tongue and Powder rivers. The area is underlain by coal beds of the Tongue River member of the Fort Union Formation (Matson and Blumer 1973). Potential natural vegetation in the quadrangle includes eastern ponderosa forest (Küchler type 16) dominated by ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopulorum*); sagebrush steppe (Küchler type 55) dominated by *Artemisia* spp. and *Agropyron* spp.; and grama-needlegrass-wheatgrass (Küchler type 64) dominated by *Bouteloua* spp., *Stipa* spp., and *Agropyron* spp. (Küchler 1964). Type 16 tends to occur at higher elevations, while types 55 and 64 are found in the more xeric areas. Detailed descriptions of existing vegetation in the Hardin NE Quadrangle are contained in Knapp (1977).

Remote Sensing

Color infrared (CIR) aerial photography of the Hardin NE Quadrangle was flown in 1976. These 9-inch (22.9 cm) by 9-inch photographs, at a 1:31,680 scale,

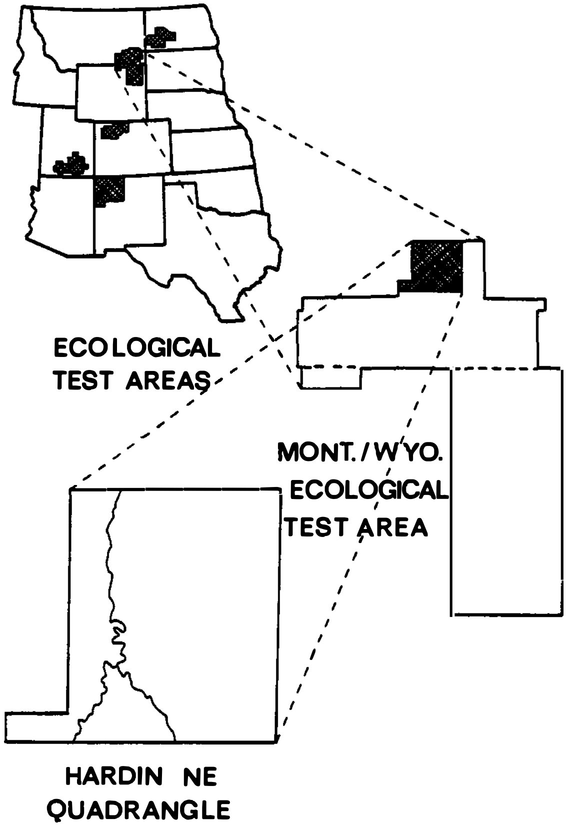

Figure 2. Location of the five regional ecological test areas and the Hardin NE Quadrangle portion of the Montana/Wyoming Ecological Test Area.

were used for the delineation of surface cover types using a minimum mapping unit of 40 acres (16.2 ha). The photography was interpreted according to the surface cover classification system shown in Table 1, although our methodology is adaptable to other land use and vegetation classifications based on existing vegetation. Cover types were mapped on one mylar overlay for urban and built-up lands, agricultural and reclaimed lands, and native vegetation; and on a second overlay for water, barren lands, and special features. Field verification studies conducted during the summer of 1978 indicated an 85 percent (± 4 percent) photo interpretation accuracy at the 95 percent confidence level.

The estimate of vertical vegetative stratification from aerial imagery was critical in this analysis. The canopy cover descriptors were used as photo interpretation guidelines only. Image analysts keyed on the first canopy cover descriptor (Table 1) for each of the nine vegetation classes (e.g., closed forest, open forest/shrubs, etc.) when delineating vegetation types (e.g., 1.1, 4.3, 7.1, etc.). Vertical profiles of the vegetational strata were summarized according to MacArthur et al. (1962), a method where the proportion of the vegetative strata describing a particular vege-

Table 1. Land use and surface cover classification system used for aerial photo interpretation.

URBAN OR BUILT-UP LANDS
- CI Commercial and industrial complexes
- RE Residential
- Transportation, communications, and utilities—U.S.G.S. map symbols

AGRICULTURAL AND RECLAIMED LANDS
- IC Irrigated croplands
- NC Non-irrigated croplands
- OR Orchards, groves, and nurseries
- FL Feed lots
- OA Other agrigultural land
- RM Reclaimed mine lands
- RL Other reclaimed lands (e.g., road right-of-way)
- RY Ranch yard

WATER
- Perennial streams—from U.S.G.S. topo maps
- Intermittent streams—from U.S.G.S. topo maps
- Irrigation canals—symbol, labeled
- Natural lakes—polygon, labeled
- Reservoirs—polygon, labeled
- Other water (e.g., ponds, stock tanks, springs & seeps)—point location, U.S.G.S. map symbol

BARREN LANDS
- Beaches—point location, symbol
- Bare exposed rock—polygon, labeled
- Cliffs, buttes—symbol
- Spires—symbol
- Mine lands (e.g., strip mines, quarries, and gravel pits—including active mines and nonvegetated spoils)—U.S.G.S. map symbol and polygon, labeled

SPECIAL FEATURES
- Priarie dog town, positive—polygon, symbol
- Prairie dog town, suspected—polygon, symbol
- Oil well—U.S.G.S. map symbol, labeled
- Dikes—symbol
- Dams—symbol

NATIVE VEGETATION
1. Closed forest—trees w/>80% canopy cover
   - 1.1 Closed ponderosa pine forest
   - 1.2 Closed juniper forest
   - 1.3 Closed ponderosa pine/juniper forest
   - 1.4 Closed aspen forest
   - 1.5 Closed riparian decidous forest
   - 1.6 Closed upland deciduous forest
2. Open forest/shrubs—trees w/20–80%, shrubs >20%, herbs <20%
   - 2.1 Open ponderosa pine forest/sagebrush
   - 2.2 Open ponderosa pine forest/upland mixed shrub
   - 2.3 Open juniper forest/sagebrush

2.4 Open juniper forest/upland mixed shrub
2.5 Open ponderosa pine-juniper forest/sagebrush
2.6 Open ponderosa pine-juniper forest/upland mixed shrub
2.7 Open riparian deciduous forest/riparian deciduous shrub
3. Open forest/herbaceous—trees w/20–80%, shrubs <20%, herbs >20%
3.1 Open ponderosa pine forest/herbaceous
3.2 Open juniper forest/herbaceous
3.3 Open ponderosa pine-juniper forest/herbaceous
3.4 Open riparian deciduous forest/herbaceous
4. Open shrubs/trees—shrubs w/20–80%, trees w/2–20%, herbs <20%
4.1 Open sagebrush/scattered ponderosa pine
4.2 Open sagebrush/scattered juniper
4.3 Open sagebrush/scattered ponderosa pine–juniper
4.4 Open upland mixed shrub/scattered ponderosa pine
4.5 Open upland mixed shrub/scattered juniper
4.6 Open upland mixed shrub/scattered ponderosa pine–juniper
4.7 Open riparian deciduous shrub/scattered riparian deciduous trees
5. Open herbaceous/trees—herbs w/20–80%, trees w/2–20%, shrubs <20%
5.1 Open herbaceous/scattered ponderosa pine
5.2 Open herbaceous/scattered juniper
5.3 Open herbaceous/scattered ponderosa pine-juniper
5.4 Open herbaceous/scattered riparian deciduous trees
6. Closed shrubs—shrubs w/>80%, herbs <20%, trees <2%
6.1 Closed sagebrush shrub
6.2 Closed upland mixed shrub
6.3 Closed riparian deciduous shrub
6.4 Closed halophytic shrub
7. Open shrubs/herbaceous—shrubs w/20–80%, herbs >20%, trees <2%
7.1 Open sagebrush shrub/herbaceous
7.2 Open upland mixed shrub/herbaceous
7.3 Open riparian deciduous shrub/herbaceous
7.4 Open halophytic shrub/herbaceous
8. Closed herbaceous—herbs w/>80%, shrubs <20%, trees <2%
8.1 Closed upland herbaceous
8.2 Closed riparian herbaceous
9. Open herbaceous/scattered shrubs—herbs w/20–80%, shrubs <20%, trees <2%
9.1 Open upland herbaceous/scattered sagebrush
9.2 Open upland herbaceous/scattered upland mixed shrub
9.3 Open riparian herbaceous/scattered riparian deciduous shrub
9.4 Open herbaceous/scattered halophytic shrub

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tation class is represented as a point within an equilateral triangle (Figure 3). The sides of the triangle are representative of understory vegetation [≤1.6 feet (≤0.5 m)], midstory vegetation [1.6–16 feet (0.6–4.9 m)], and overstory vegetation [≥16 feet (≥5.0 m)].

Vegetation classes listed in Table 1 are represented as points within the triangle in Figure 3. For example, point 1 (vegetation class 1) represents a habitat profile of dense woodland with a very limited midstory and understory; point 6 (vegetation class 6) represents a dense shrubland with only an occasional tree and limited

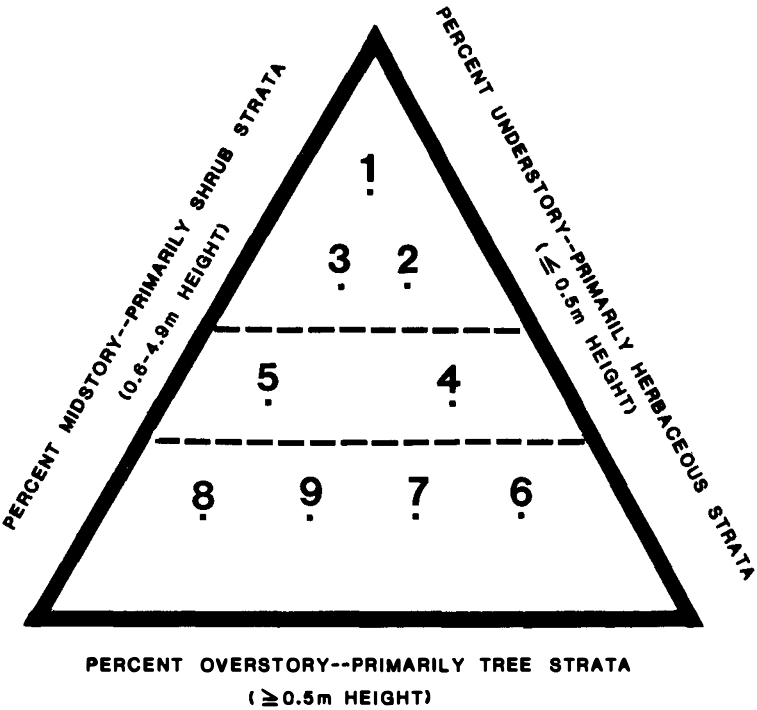


Figure 3. Generalized profile of the nine native vegetation classes listed in Table 1. The perpendicular distance to each of the three sides from any point represents the proportion of the vegetative strata describing that vegetation class. Dashed lines indicate the vegetation classes that were grouped for final strata habitat diversity calculations. Representation after MacArthur et al. (1962).

herbaceous cover. Vegetation classes such as 1, 6, and 8 (grassland), located near the vertices of the triangle, have less structural variability than the other surface cover types.

Original mylar overlays (1:24,000 scale) of the surface cover maps were digitized. The digital map data, following entry and editing, were transferred to a computerized map overlay and statistical system for storage, retrieval, and further analysis (Gropper and Reed 1979).

Wildlife Species–Habitat Use Data Base

A terrestrial vertebrate species–habitat use data base was developed for the M/W ETA. This data base contains feeding and breeding information that relates 235 species of birds, 74 species of mammals, 14 species of reptiles, and 6 species of amphibians to the surface cover types in our classification system. The data base also aggregates the 329 species into 28 life forms, similar to those described by Thomas et al. (1976), according to habitat use for reproduction and feeding. Sources for the data base included published information on species distribution and habitat use patterns and the professional opinions of state and federal biologists. Observations of habitat use by wildlife species, obtained during the 1978 field studies, were used to supplement the data base.

Breeding Bird Surveys

A field validation study was conducted in the Hardin NE Quadrangle during the summer of 1978 to test the correlative relationships between surface cover characteristics mapped from the CIR photography and actual wildlife use of the cover types. Three hundred and thirty of the complete sections of land that are contained in the Hardin NE Quadrangle were divided into six habitat diversity classes based on the number of mapped polygons per section. Eight sections were randomly selected from each of the six diversity classes for ground sampling.

Two crews of two persons each sampled the breeding bird species present in 38 of the 48 randomly selected sections during June and the first half of July. Sampling ended in mid-July due to a marked decrease in breeding bird activity. Birds were intensively sampled in each of the 38 sections by one crew for two consecutive days.

The sampling design consisted of 16 sampling stations systematically located at 220 yard (201 m) intervals in a square approximately one-quarter mile (0.4 km) inside the section boundary. Bird censusing began one-half hour before sunrise and continued until bird activity dropped off significantly, usually about 1000 to 1100 hours MDT. Each bird seen or heard at a sampling station during a 3-minute period after normal feeding and singing activity had resumed was recorded. All birds flushed or heard while the observer was walking between stations also were recorded. Flushing-transect and observation-station samples were treated separately so that the same bird could be recorded on both types of samples. Field notes were taken on cassette recorders and later transcribed to data forms.

Habitat and Bird Species Diversity Determinations

Digitized surface cover information was computer manipulated to automatically calculate and summarize a variety of habitat parameters of potential ecological interest, including: (1) number, identity, and area of cover types per section; (2) number of mapped polygons of each cover type per section; (3) linear amount and identity of edge segments per section; and (4) proportion of each section occupied by individual cover types.

These basic data were used to calculate diversity indices for vegetation structure and composition in the 38 field-sampled sections using the Shannon-Weaver formula (Shannon and Weaver 1963). The interspersion of cover types within sections, determined from the proportion of the area occupied by the different vegetation types mapped, was used to calculate the habitat cover type diversity (HCTD) index.

A grouped cover type habitat diversity index was calculated for each section by combining the following vegetation types: (1) Ponderosa pine type—types 1.1–1.3, 2.1–2.6, and 3.1–3.3; (2) riparian tree and shrub type—types 1.5, 2.7, 3.4, 4.7, 5.4, 6.3, 7.3, and 9.3; (3) sagebrush steppe type—types 4.1–4.6, 6.1, 6.2, 6.4, 7.1, 7.2, and 7.4; and (4) upland grassland type—types 5.1–5.3, 8.2, 9.1, 9.2, 9.4, IC, NC, OA, and RL.

Habitat diversity indices for the vertical or structural profile of the vegetation types present in each section were determined for all possible combinations of the nine native vegetation classes listed in Table 1 and shown in Figure 3. The index for the structural profile obtained by combining the vegetation classes shown in Figure 3 is termed the habitat strata diversity (HSD) index.

Faunal diversity and juxtaposition indices were also calculated for each of the 38 sample sections. The faunal diversity index is the summation of the products of the area of each cover type in the section multiplied by the number of vertebrate species utilizing that type for breeding. The juxtaposition index is a relative measure of the quality of habitat edge calculated by summing the products of the length of each edge type in the section multiplied by the number of vertebrate species breeding in the cover types that make up the edge. These indices utilized the information in the wildlife species–habitat use data base.

Bird species diversity (BSD) values were calculated using the Shannon-Weaver formula and were based on the proportion of the total birds observed per sample section that belonged to each bird species observed in that section. Proportions were obtained by combining the data from the flushing-transect and observation-station samples.

Multiple Regression Analysis

Several independent variables were included in the stepwise multiple regression analysis to determine the most efficient predictor of wildlife habitat quality. Independent variables that were tested for each of the 38 sections included the: (1) number of polygons of individual vegetation or cover types; (2) number of polygons of grouped vegetation or cover types; (3) number of individual vegetation or cover types; (4) number of grouped vegetation or cover types; (5) miles of edge per square mile; (6) faunal diversity index; (7) juxtaposition index; (8) HCTD; and (9) HSD. Dependent variables used in the regression analyses were BSD, number of bird species observed per section, and number of bird life forms present per section.

Results and Discussion

Prediction of Wildlife Habitat Quality

A summary of the stepwise multiple regression analyses for predicting BSD, number of bird species, and number of life forms from the independent variables obtained from aerial photography is presented in Table 2. Independent variables were not included in the prediction equations if they were not significant ($P<0.20$). The most efficient predictor of potential wildlife habitat quality was the correlation of BSD with HSD and HCTD ($r=0.74$). The BSD equation required fewer variables and accounted for more of the total variability than did the other two equations (Table 2). The two measures of habitat diversity (HSD and HCTD) used to predict BSD are the same habitat indices found meaningful in onsite studies of BSD by MacArthur et al. (1962).

Bird species diversity values are therefore related to both the complexity of vertical vegetative structure and the mixture of vegetation types, characteristics interpretable from aerial photography. Habitat quality is equated with habitat

Table 2. Summary of prediction equations derived to assess habitat quality.

Dependent Variable	Independent variables for prediction equation[a]	Multiple r	Significance
BSD	$1.44 + 0.56(A) + 0.32(B)$	0.74	$P<0.01$
No. bird species	$6.83 + 0.43(C) - 1.37(D) + 9.55(B) + 2.32(E) - 9.17(F)$	0.72	$P<0.01$
No. life forms	$7.00 + 0.46(C) - 1.95(D) + 0.60(G)$	0.60	$P<0.01$

[a]Where: A = HSD = Habitat Strata Diversity Index
B = HCTD = Habitat Cover Type Diversity Index
C = EDGE = Miles of Edge Per Square Mile
D = JUXT = Juxtaposition Index
E = NGCT = Number of Grouped Cover Types
F = HGCTD = Habitat Grouped Cover Type Diversity Index
G = NCT = Number of Individual Cover Types

diversity in our analysis; the justification for equating them is that: (1) BSD is correlated with the number of bird species observed ($r=0.75; P<0.01$); and (2) the number of bird species observed is correlated with the number of life forms ($r=0.76; P<0.01$). The number of life forms present indicates the niche potential for vertebrate species.

Our analysis suggests that resource development within a region will impact wildlife and wildlife habitat the least when that development is confined to large homogeneous areas with little vegetative stratification and relatively low cover type diversity. We realize that high production of wildlife biomass is sometimes associated with areas of little habitat diversity, such as bison on the Northern Great Plains, and that habitats beneficial to the total faunal community may not always be appropriate for an individual species perceived to be of high economic or social importance.

Lands can be stratified on the basis of the BSD prediction equation and the BSD values can be used to evaluate or rank regional wildlife habitat quality and/or assist in preplanning onsite surveys. A maximum BSD value can be calculated as follows. The minimum map unit for mapping surface cover types was 40 acres (16.2 ha), or a maximum of 16 polygons in a 640 acre (259 ha) section. If each type occupies 40 acres or 6.25 percent of the surface cover in a section, a maximum HCTD value of 2.77 occurs. The overstory and midstory canopy coverage can be projected to the ground and the herbaceous ground cover estimated. Our ground truthing only allowed us to partition 100 percent of surface coverage among the overstory, midstory, and understory. Consequently, a maximum HSD value of 1.10 occurred when each of the three strata covered 33.3 percent of the surface cover. The regression equation (Table 2) predicted a maximum BSD value of 2.94 when HSD and HCTD values were maximum.

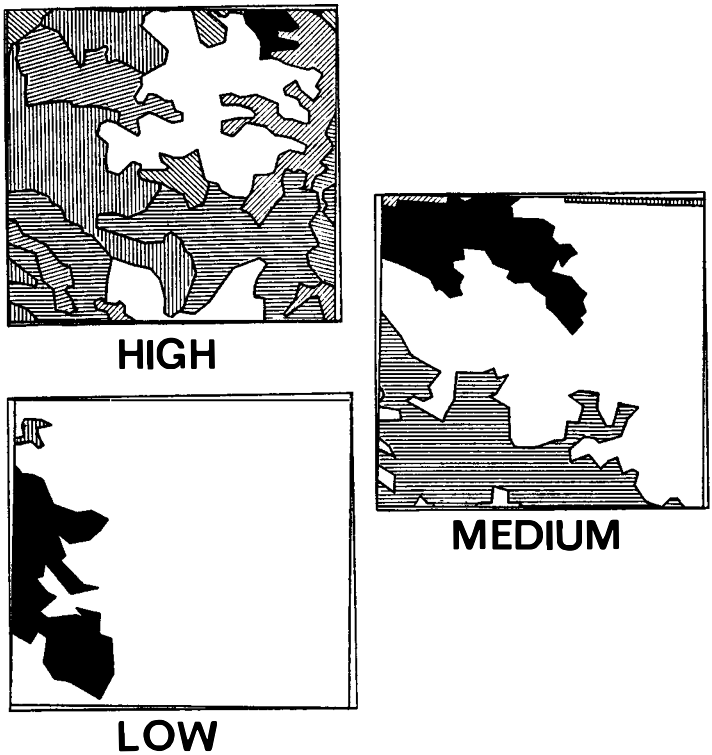
The stratification of habitat on the basis of the BSD values could occur as follows. For example, areas with a BSD value less than 60 percent of the maximum value may have poor habitat quality while areas with greater than 85 percent of the maximum value may be considered high quality habitat. Eight of the 38 test sections had BSD values greater than 2.50 (85 percent of 2.94) and five sections had BSD values less than 1.76 (60 percent of 2.94). Physical characteristics and other attributes of areas of high, medium, and low habitat diversity are listed in Table 3.

Table 3. Mean ecological characteristics of the 38 test sections in the Hardin NE Quadrangle determined to be of high, medium, and low wildlife habitat quality.

Habitat quality	No. of sections	Measured BSD	No. bird species observed	No. bird life forms represented	No. Individual cover types mapped	No. polygons mapped	Miles edge per square mile	Percent Ponderosa pine	Percent Sagebrush steppe	Percent Upland grassland	Percent Riparian tree & shrub
High	8	2.59	24.8	13.4	6.1	18.4	10.0	36.6	57.8	4.7	0.9
Medium	25	2.18	19.8	11.9	5.1	14.8	7.9	25.4	71.9	2.6	0.2
Low	5	1.47	14.0	9.4	4.8	8.0	4.7	6.6	70.3	20.4	2.7

Sections with high BSD values, reflecting a greater diversity of niches, contained more bird species representing more life forms than did other sections (Table 3). These areas contained more vegetation types, more polygons of different vegetation types (Figure 4), and averaged 10 miles per square mile (6.2 km per km^2) of edge. The proportion of woodland, sagebrush steppe, and grassland were more equal than in habitats of lower quality.

Areas of low BSD values contained the fewest bird species, were more homogeneous, contained few polygons (Figure 4), and averaged less than 5 miles per square mile (3.1 km per km^2) of edge. These sections were mostly sagebrush steppe with a small amount of grassland and a low HSD.



Section Characteristics	Wildlife Habitat Quality HIGH	MEDIUM	LOW
Number of Polygons	25	12	3
Number of Cover Types	8	5	3
Miles of Edge/Sq mile	11.1	6.2	2.8
Habitat Strata Diversity (HSD)	1.071	0.673	0.036
Habitat Cover Type Diversity (HCTD)	1.705	0.937	0.410
Measured BSD	2.648	2.120	1.764
Predicted BSD	2.585	2.117	1.591

Figure 4. Simulated digital maps of surface cover types in representative sections of high, medium, and low quality wildlife habitat with respective section characteristics.

Portions of this region with very extensive and homogeneous grassland associations will have an even more diminished strata diversity and a reduced diversity in cover types. These lands were not adequately represented in our test sections even though abundant in the region. They are estimated to have a low habitat and bird species diversity. Low BSD values of 0.89 to 1.23 have been calculated for three grassland habitats: the midgrass upland prarie in Kansas, the northern plains of Saskatchewan, and the shortgrass prairie of Colorado (Cody 1966).

The equation predicting BSD values from HSD and HCTD values developed in this analysis is probably most valid in the ponderosa pine–sagebrush steppe–mixed grassland complex of the Northern Great Plains. Peterson (1975) reported that average BSD values varied by ecological strata or ecoregions and that the tendency for one ecological strata or one ecoregion to have higher BSD values than another is a function of plant community diversity and is constant between years. He also suggests that data on large heterogeneous areas can be meaningfully grouped by physiographic regions that have a similar type of vegetative structure or diversity.

Our procedure is based on analyzing existing rather than potential vegetation for an area. We realize that successional stages in plant associations often show a progressive increase in wildlife species numbers (Balda 1975) and that our estimates of habitat diversity are current and possible transitory appraisals. We believe that static assessments of habitat diversity are valid, however, for assisting in the determination of suitable areas for resource development because present habitat values receive the immediate impact of development.

Our technique is useful for providing a rapid and uniform assessment of wildlife habitat quality for large regions. Bird species diversity indices represent a useful indication of the habitat quality of plant communities. Combined with the use of aerial photography and a computerized geographic information system with analysis capabilities, the technique is rapid and inexpensive when compared to conventional field inventory techniques.

The level of information provided by our methodology should be used early in the planning process to assist in the determination of areas that are suitable or unsuitable for development from a wildlife perspective. Use of our technique can reduce the number of onsite inspections that are necessary by stratifying lands before inspections are started. Changes in habitat values over time also can be assessed if those changes affect surface vegetation in a manner that can be observed and interpreted from aerial photography.

Application in the Planning Process: An Example

The wildlife habitat quality values derived by the methodology described in this paper can be combined with other wildlife, wildlife habitat, and energy resource information early in the land use planning process. Figure 5 represents a 7 and one-half minute quadrangle in southeastern Montana and Table 4 contains some of the various kinds of environmental information that could be provided to decision makers involved in the determination of suitable sites for energy development in the sample quadrangle. Tracts A, B, C, and D (Figure 5) represent proposed coal leases. Striped sections have low habitat diversity and predicted BSD indices while nonstriped sections have medium values. No sections of high habitat or bird species diversity occur in this quadrangle. Two permanent and several intermittent streams, representing the very limited extent of riparian habitat in this area, are also plotted in Figure 5.

Habitat diveristy or quality, location of permanent streams with riparian vegetation, eagle nest sites, grouse leks, and pronghorn (*Antilocapra americana*) and mule deer (*Odocoileus hemionus*) winter range are identified by section in Table 4.

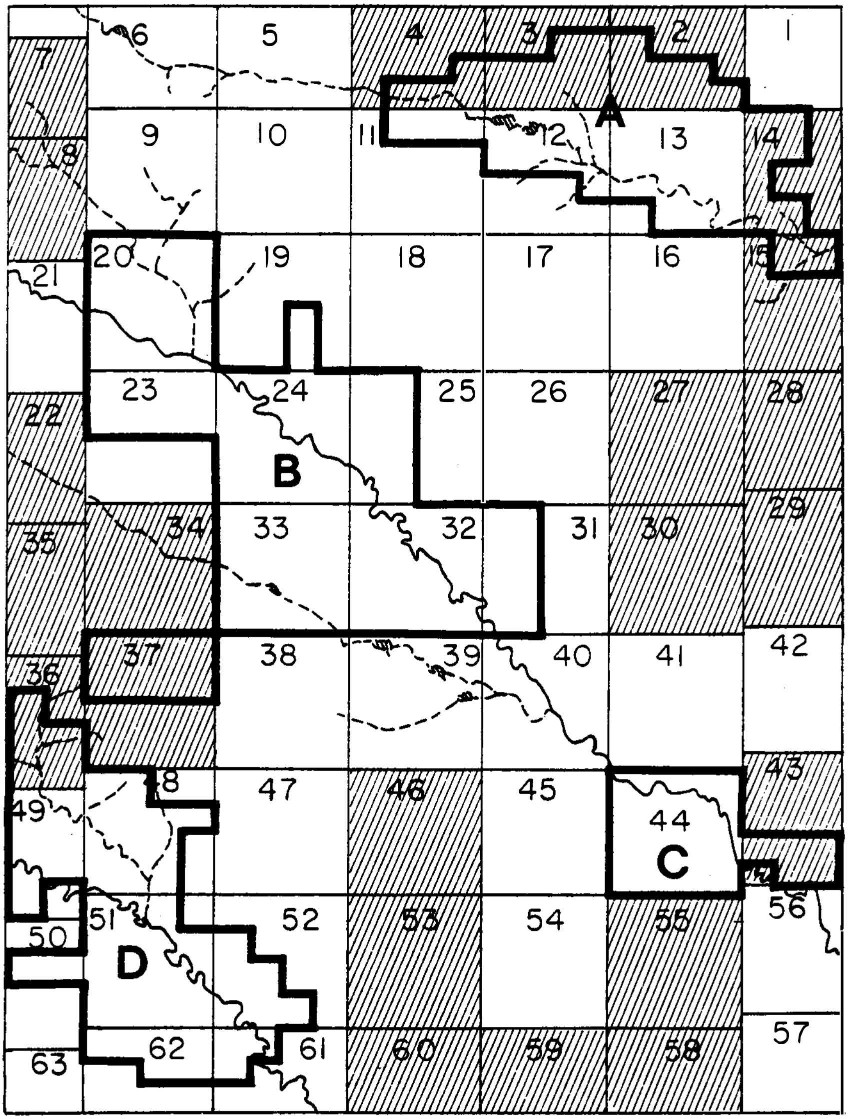


Figure 5. Map of sample quadrangle in southeastern Montana showing four possible coal development tracts (A, B, C, and D), two permanent creeks, and several intermittent creeks. Numbers identify sections listed in Table 4. Striping indicates sections of low wildlife habitat quality.

Table 4. Summary of wildlife habitat quality, exclusionary factors and coal reserve data by section (see Figure 5 for section location) for a sample quadrangle in southeastern Montana.

Section	Wildlife habitat quality (closed box=medium, open box=low)	Water sources with riparian habitats (closed box=present, open box=absent)	Bald or golden eagle nest sites (closed box=present, open box=absent)	Sage grouse and/or sharp-tailed grouse leks (closed box=present, open box=absent)	Mule deer winter range (closed box=present, open box=absent)	Antelope winter range (closed box=present, open box=absent)	Minerals owned by Federal Government (closed box=no, open box=yes)	Coal lease proposed for section (closed box=no, open box=yes)	Strippable coal (closed box=absent, open box=present) Feet of overburden < 50 ft	50-100 ft	> 100 ft	Suitability for mining (closed box=unsuitable, open box=suitable)
1	■	□	■	□	■	■	□	■	■	□	■	□ * (a)
2	□	□	□	□	■	□	□	□	□	□	□	□
3	□	□	□	■	■	■	□	□	□	□	□	□ *
4	□	□	□	□	■	■	□	□	■	□	□	□
5	■	■	■	■	■	□	□	■	■	■	□	■
6	■	□	■	□	■	□	□	■	□	□	□	□
7	□	□	□	□	□	□	□	■	□	□	□	□
8	□	□	□	□	□	□	□	■	□	■	□	□
9	■	□	□	□	□	□	□	■	□	□	□	□
10	■	□	□	□	■	■	□	■	□	□	■	□
11	■	□	□	□	■	■	□	□	□	□	□	□
12	■	■	□	□	■	□	□	□	■	□	□	■
13	■	□	□	□	■	□	□	□	■	□	□	□
14	□	□	□	□	□	□	□	□	■	□	□	□
15	□	□	□	□	■	□	□	□	■	■	□	□
16	■	□	□	□	■	□	■	■	■	■	□	□
17	■	□	□	■	■	□	□	■	□	■	□	□ *
18	■	□	□	■	■	□	□	■	□	□	■	□ *
19	■	□	□	□	■	□	□	□	□	□	□	□
20	■	■	□	□	■	□	□	□	□	□	□	■
21	■	■	■	□	□	□	□	■	■	□	□	■
22	□	□	□	□	□	□	□	■	□	□	□	□
23	■	□	□	□	□	□	□	□	□	□	□	□
24	■	■	□	□	□	□	□	□	□	■	□	■

Table 4. Continued.

Section	Wildlife habitat quality (closed box=medium, open box=low)	Water sources with riparian habitats (closed box=present, open box=absent)	Bald or golden eagle nest sites (closed box=present, open box=absent)	Sage grouse and/or sharp-tailed grouse leks (closed box=present, open box=absent)	Mule deer winter range (closed box=present, open box=absent)	Antelope winter range (closed box=present, open box=absent)	Minerals owned by Federal Government (closed box=no, open box=yes)	Coal lease proposed for section (closed box=no, open box=yes)	Strippable coal (closed box=absent, open box=present) Feet of overburden < 50 ft	50-100 ft	> 100 ft	Suitability for mining (closed box=unsuitable, open box=suitable)
25					■			■				
26	■				■			■			■	
27					■			■				
28					■	■		■	■			
29					■			■	■	■	■	
30					■			■			■	
31	■	■			■							■
32	■	■			■							■
33	■					■				■		
34						■		■		■	■	
35								■				
36		■										
37											■	
38	■						■	■				
39	■		■			■		■				*
40	■	■			■			■	■	■		■
41	■		■		■			■				*
42	■		■		■			■	■	■		*
43					■				■	■		
44	■	■							■	■		■
45	■					■		■	■	■		
46				■		■		■			■	*
47	■							■			■	
48	■								■			

Table 4. Continued.

Section	Wildlife habitat quality (closed box=medium, open box=low)	Water sources with riparian habitats (closed box=present, open box=absent)	Bald or golden eagle nest sites (closed box=present, open box=absent)	Sage grouse and/or sharp-tailed grouse leks (closed box=present, open box=absent)	Mule deer winter range (closed box=present, open box=absent)	Antelope winter range (closed box=present, open box=absent)	Minerals owned by Federal Government (closed box=no, open box=yes)	Coal lease proposed for section (closed box=no, open box=yes)	Strippable coal (closed box=absent, open box=present) Feet of overburden: < 50 ft	50-100 ft	> 1 00 ft	Suitability for mining (closed box=unsuitable, open box=suitable)
49	■	■	□	□	□	□	□	□	□	□	□	■
50	■	□	□	□	□	□	□	□	■	□	□	□
51	■	■	□	□	□	□	□	□	□	□	□	■
52	■	■	□	■	□	□	□	□	□	□	□	■
53	□	□	□	□	□	□	□	■	□	□	■	□
54	■	□	□	□	□	■	□	■	□	■	■	□
55	□	□	□	□	■	■	□	■	■	■	□	□
56	■	□	□	□	□	□	□	□	■	■	□	□
57	■	■	□	□	□	□	□	■	■	■	■	■
58	□	□	□	□	■	□	■	■	■	■	■	□
59	□	□	□	□	□	□	□	■	■	■	■	□
60	□	□	□	□	■	□	□	■	■	■	■	□
61	■	■	□	□	□	□	□	□	□	□	□	■
62	■	□	□	■	□	□	□	□	■	■	□	*
63	■	■	□	□	□	□	□	□	■	■	□	■

(a)
Section is suitable for mining but non-disturbance area or zone should be maintained around eagle nest or grouse lek.

The area was not known to provide habitat for any rare or threatened species. Federal mineral ownership and the location of the proposed coal leases are listed along with the presence of strippable coal under three depths of overburden, derived from published maps by the Montana Bureau of Mines and Geology.

A coal seam, 10 to 15 feet (3.0 to 4.6 m) thick, occurs under less than 50 feet (15.2 m) of overburden over about 15 percent of the land area. Little of this coal is included in proposed lease tracts A, B, C, and D. Coal maps of this sample quadrangle, however, indicate that an extensive coal seam, approximately 50 feet

(15.2 m) thick, occurs about 500 feet (152.4 m) below the surface in upland areas. Permanent and intermittent streams and other geologic processes have worn away 300 feet (91.4 m) of the overburden in some areas, exposing cliff faces and producing alluvial valleys where riparian habitat occurs. The remaining depth of overburden is frequently only 100 to 200 feet (30.5 to 61.0 m) above the coal seam. The four proposed lease sites include riparian areas (Figure 5), where access to the coal seam is least expensive.

Riparian habitats in this geographical region provide potential breeding habitat for 172 verbebrate species and potential feeding habitat for at least 216 verbebrate species, exclusive of fishes. Sixty-two of these terrestrial vertebrate species breed only in riparian or other wetland sites while an additional 10 species breed only on cliffs, spires, rimrock, and/or talus outcrops frequently associated with land forms containing streambeds. Wetland habitats and associated cliffs cover only about one percent of this region but provide essential breeding habitat for 72 terrestrial vertebrate species. Some areas of riparian habitat are also important big game winter range and/or contain grouse leks and eagle nests. Therefore, permanent and intermittent streams and their associated riparian vegetation are high quality habitats for wildlife and, in this example, represent unsuitable sites for strip mining in southeastern Montana.

Twenty-nine of the 63 sections, partially or totally within the sample quadrangle, are proposed coal lease sites (Table 4). Eleven of these 29 sections are considered unsuitable sites for strip mining because they contain the highest wildlife habitat diversity in the area and important streamers of riparian vegetation along permanent streams.

Suitable sites within proposed coal lease areas include 14 sections of land, although nine of these sections are winter range for antelope and/or deer. Mining lease agreements should carry the stipulation that impacts on big game habitat in these sections would be minimized. There are two sections that contain active grouse leks, indicating a need for disturbance free areas around the leks. Seven of the 29 sections proposed for leasing have low vegetative diversity, no riparian habitat, no grouse leks or eagle nests, and provide no winter range for pronghorn or antelope. These sections are the most logical choices for lease development from a wildlife habitat point-of-view.

There are 24 additional sections in the sample quadrangle with low vegetation diversity, no riparian habitat, and known coal reserves that would be suitable sites for resource development. Some of these sections provide winter range for mule deer and antelope or contain grouse leks and eagle nests, requiring leasing stipulations to minimize mining impacts. These sections, with coal under 50 to 150 feet (15.2 to 45.7 m) of overburden, should be considered as alternative lease sites because of their low relative value as habitat for wildlife in the region.

Planners and decision makers will need to weigh the value of protecting the existing wildlife habitat against the desirability of developing coal reserves for each proposed lease site. Conflicts in objectives will occur, such as the protection of riparian habitat with its high biological value versus the favorable overburden to strippable coal ratios in these areas. The application of the procedure presented here can help resolve these conflicts by placing natural resource questions in perspective. The procedures also alert planners and decision makers to unique habitat features, such as eagle nests and other raptor cliff nesting sites, that require protective leasing stipulations if the area is mined (Bureau of Land Management 1978). The display of environmental data, similar to Table 4, provides the necessary data to identify areas where development of valuable energy reserves can occur with the least impact on important, rapidly diminishing wildlife habitat.

Recommendations for Future Natural Resource Inventories and Assessments

The following recommendations are offered regarding future natural resource inventories and/or assessments based on our experience with this project.

1. All natural resource inventories would benefit from greater coordination between federal, state, and private sectors. Greater coordination would help eliminate duplication of effort and allow for cost sharing of materials, planning, and conduction of inventories.
2. Federal, state, and private inventory agencies and groups should agree upon and utilize a common surface cover classification system to reduce duplication of effort and help assure compatability of data bases.
3. The hierarchy of a surface cover classification system should include descriptors or categories of existing vegetation. Wildlife and wildlife habitat assessments are most meaningful if current or existing vegetation is evaluated.
4. Agency evaluations are needed to determine the "optimum" minimum map unit size(s) required for specific mapping applications. Standardization of aerial photography scales and mapping conventions will help assure compatability of map based data and reduce photo interpretation, data entry, and data compilation costs.
5. Vegetation inventories should include structural or strata descriptors of the vegetation polygons that are mapped or field sampled. Structural vegetative parameters such as numbers and heights of vegetative layers or strata present are important for evaluating habitat quality—especially for birds.
6. Common field inventory methodologies should be adopted by agencies that share resource management responsibilities. This will help assure interagency use and credibility of data.
7. Wildlife inventories should document species use of defined vegetation or cover types and provide numerical estimates of species abundance where possible. Relative abundance estimates such as abundant, common, uncommon, and rare are not adequate for diversity index calculations.
8. Computer compatability of hardware, software, and data bases is essential, especially when different agencies have common needs for the information. Interagency access to the data bases must be feasible and efficient.
9. More strategies and objective analyses are needed for integrating the complex and varied kinds of information obtained from resource inventories and required in the land use planning process. Decision makers and planning teams are continuously confronted with resolving renewable and non-renewable resource management conflicts although few strategies and methodologies exist to assist them.

Summary

Wildlife habitat quality of regional landscapes can be uniformly and rapidly evaluated by using the procedure described in this paper. Existing surface cover information was photo interpreted on recent CIR aerial photography according to a structural classification system, digitized, and computer manipulated to automatically calculate and summarize numerous habitat parameters. Basic habitat parameters calculated include the: (1) number, identity, and area of cover types per section; (2) number of mapped polygons per section; (3) linear amount and identity of edge segments per section; and (4) proportion of each section occupied by individual cover types.

Habitat diversity indices were calculated from the basic cover type information and correlated with breeding bird survey data using stepwise multiple regression analyses. Indices and habitat parameters used as independent variables in this analysis included the: (1) number of polygons of individual and grouped vegetation or cover types; (2) number of individual and grouped vegetation or cover types; (3) miles of edge per square mile; (4) faunal diversity index; (5) juxtaposition index; (6) habitat cover type diversity (HCTD) index; and (7) habitat strata diversity (HSD) index.

Three dependent variables—bird species diversity, number of bird species observed per section, and number of bird life forms per section—were individually correlated with the independent variables of habitat diversity to determine the most efficient prediction equation. The most efficient predictor of potential wildlife habitat quality was the correlation of BSD with HSD and HCTD ($r=0.74$, $P<0.01$). The BSD prediction equation required fewer variables and accounted for more of the total variability than did the other two equations. The data suggest that wildlife habitat quality is equated with habitat diversity and that BSD values, which are commonly determined for small, homogeneous sites, can be reliably determined for, and applied to, very large areas of heterogeneous cover types.

The BSD prediction equation was demonstrated to have regional application in the statification of wildlife habitat quality. Land areas within the same ecological region can be "ranked" into units, such as legal sections of land, of high, medium, and low wildlife habitat values after the relationship of vertebrate use of surface cover types is established.

An example of the utility and application of the information obtained with our procedure is presented for a sample quadrangle in southeastern Montana where future expansion of ongoing coal strip mining is possible. The procedure provides planners and decision makers with uniform wildlife habitat quality rankings for large contiguous areas, in contrast to the limited wildlife information currently used in the planning process. These rankings of wildlife habitat quality should be used in early planning stages to help resolve conflicts between energy resource development and wildlife habitat protection.

Suitable sites for coal mining, from a wildlife perspective, can be identified on the basis of their habitat diversity and predicted BSD values. These preliminary suitability rankings can then be modified by the application of exclusionary factors such as the presence of rare or endangered species, cliffs, riparian habitats, and archeological or historical sites. In the final analysis, decision makers will have to collectively weigh wildlife, environmental, energy resource, social, and economic data to arrive at final suitability recommendations for resource development. More research is needed on strategies for integrating these complex kinds of information in the land use planning process.

Recommendations are offered for making future natural resource inventories and assessments more efficient and cost effective.

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RUN WILD II: A Storage and Retrieval System for Wildlife Data

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The need for a system to store and retrieve wildlife habitat information became evident in the early 1970s as a mass of data accumulated in professional journals, state game and fish reports, and other publications. At about the same time, computer technology was advancing rapidly and mass storage became practical and economical. Because the need existed and technology was available to develop a storage and retrieval system, the Rocky Mountain Forest and Range Experiment Station and the Southwest Region of the USDA Forest Service undertook this job for biologists in Arizona and New Mexico. The end product, called "RUN WILD," became operational in 1976. A second version, RUN WILD II, was made available to wildlife biologists in November 1978, and RUN WILD III will be ready by October 1979.

The RUN WILD System

RUN WILD has been described in detail in two USDA Forest Service publications (Patton 1978, Casner et al. 1978). The term "system" is used instead of computer program in describing RUN WILD, because it is a series of unique data files designed to provide information in an orderly manner. The computer program used in RUN WILD enables the user to link the files and is only one part of the total system.

RUN WILD contains three levels of information (Inventory, Species Habitat Associations and Management Data) with each level having several categories. These levels start with general information in the inventory file and increase in detail to very specific data in the management files. Categories of information in the system are:

1. Inventory
   A. Vegetation types in Arizona and New Mexico
   B. Counties
   C. National Forests
   D. Key habitat factors
   E. Vertebrate species
2. Species Associations
   A. Habitat species list
      (1) By vegetation type
      (2) By key habitat factors

B. Geographic species list
   (1) By county
   (2) By National Forest
3. Management Information
   A. Species summaries
      (1) Common and scientific name
      (2) General distribution
         a. Counties
         b. National Forest
      (3) Protection status
         a. Arizona
         b. New Mexico
         c. Federal
      (4) Vegetation types
      (5) Food habits
      (6) Cover requirements
      (7) Key habitat factors
      (8) Management practices
      (9) Special comments
   B. References by species

How the System Was Developed

From the start users (field biologists in Arizona and New Mexico) were involved in determining what would go into the RUN WILD System and in what format. To develop the files, biologists were asked what types of decisions they made and what data they needed to make these decisions. From their responses a flow chart was prepared that included all the information in the three levels. Quality of the data in the files is high because it came from biologists with knowledge of the five vertebrate groups. In addition to their own data and personal observations, they obtained information from published literature and unpublished reports. Data were entered on a form corresponding to a computer card. This form was designed to expedite data transfer directly to computer cards and was a key factor in developing the computer program.

To date the RUN WILD System for Arizona and New Mexico has cost approximately $75,000 over a four-year period to synthesize information for 745 vertebrate species in 8 different files. The cost averaged about $100 per species which is very reasonable considering the amount and quality of data obtained.

How is RUN WILD Being Used

Field biologists have access to RUN WILD II through computer printouts and remote terminals. Computer printouts are provided each cooperating agency at the time of update. The system is also on the USDA computer at Fort Collins, Colorado and can be accessed by telephone console. When access is by remote terminal, the user can take control of the program and ask a selected set of questions, or the computer can be allowed to proceed through a series of questions and the user responds with simple "yes" or "no" answers or numerical codes. A survey of biologists, 8 months after they were trained in a workshop to use the system, indicated they used the printout 80 percent of the time and a computer console the remaining 20 percent.

RUN WILD is more than a storage and retrieval system because of the way data are filed and cross referenced. It can be used for inventory and assessment purposes and also for decision making. For example, the list of animal species by vegetation types is an inventory of what potentially can be found in a particular type. The biologist must then determine by field surveys what species are in his area. By comparing what should be there and what is actually there an assessment can be made of existing versus potential habitat.

Once the list of animals is obtained for a vegetation type, a more detailed description of the habitat requirements is available for each species in the management file. These individual species summaries provide information on life requirements such as food and cover and, in many cases, give an indication of what habitat factors should be measured in field surveys. Tradeoffs can be determined for land management practices by comparing a species' life requirements to proposed changes in the habitat. In some instances, as for game animals, the species management file has a considerable amount of data. Species files for amphibians, fish, reptiles and nongame birds contain the least information, but current and planned research by many cooperating agencies will increase the amount of data for these species.

What the System will not Do

No system for storing and retrieving data is going to meet everyone's needs. The RUN WILD System, as it is now, will not provide site-specific information such as animal distribution by local geographic areas—mountain ranges, watersheds, streams, etc. There are no files or data pertaining to animal populations or the demand for commercial and recreational uses. Although there is considerable data in the files, the system does not allow multiple or nested questions to be asked. For example, you cannot obtain animal species in a vegetation type on a National Forest within a county in one question. The questions can be answered, but at the present time some hand matching of the three categories is required. This feature will be changed in future revisions.

Many users want information on the effects of land treatments on individual species or groups of wildlife. Some of this is available in individual species files but not in the form of a simulation or decision model with alternatives. There is no information in the files on species' physical characteristics or measurements, reproductive success or potential and subspecies are not included unless they are on a threatened and endangered list.

Future Development

The RUN WILD System is simple and easy to change. Although several items outlined in the previous section could have been part of the system, we decided to first add files that were relatively easy to compile and would make a large contribution to synthesizing masses of data into usable form.

Development of RUN WILD will continue, and new files will be added that will include:

1. Wildlife food plants of the Southwest;
2. Antelope, deer and elk habitat management;
3. Aspen management for wildlife;
4. Riparian habitat management;
5. Snag management for nongame birds;
6. Species habitat profiles;
7. Effects of fire on wildlife;
8. Effects of grazing on wildlife;
9. Fish habitat classification;
10. Timber–wildlife relations in ponderosa pine and mixed conifer; and
11. Grass, forbs, browse and trees associated with each vegetation type.

The data will be ordered, when practical, in a hierarchical structure so that information can be obtained for use at the national, regional and local levels. The data accumulating in the RUN WILD files are gradually forming the *nucleus for a general habitat model by ecosystem*.

Because data in RUN WILD has expanded rapidly, it is difficult to accomodate all the requests for information and assistance. One problem is how to provide copies of the complete computer printout to other agencies or to individuals in research and management. The physical size and weight of the printout (1,600 computer pages, 13 pounds) now prohibits distribution through normal procedures. The amount of data accumulated for the Southwest had to be stored in a computer. However, since the information is now in a systematic order, printouts have become a useful working tool, and remote terminals are being used less.

Some files, particularly those of inventory items, are permanent or change very little and could be kept in a loose-leaf notebook. Another method being considered is to transfer all the information stored in the computer directly to microfiche. Any way that is selected to provide data from the RUN WILD System must consider cost and ease of use. These factors will be examined this year, but it appears that several options will be necessary to meet user needs.

Suggestions for Developing a Storage and Retrieval System

The RUN WILD System was developed slowly to avoid making large costly mistakes. In addition, the following procedures used in its development will also insure success in developing any storage and retrieval system:

1. Involve the users and prepare a flow chart of questions they want answered. Determine the format and units to be used in answering the questions.
2. Identify the data management system needed to manipulate the records and store the information.
3. Develop a form and a set of clear, concise instructions to record the data in an orderly manner.
4. Use hierarchical systems when possible.
5. If access to the computer program is by remote terminal, keep answers to questions simple, such as yes or no. Use code numbers for animals, vegetation types and inventory items. Numbers are easier to use than names.
6. Do not include information in the system that is not specifically requested by the users.
7. Use an oversight committee to set priorities on files or records to be added.

8. Develop the simple files or records first and test them to get experience in developing a total system.

Suggestions for Developing an Inventory and Assessment System

Two types of information must be present before an assessment can be made of wildlife habitat conditions. First there needs to be specific knowledge of the life requirements of individual species, and second, there needs to be knowledge of these requirements as they exist in the field. These two conditions are then matched in the assessment process to arrive at some subjective rating.

RUN WILD is not an inventory and assessment system but it can store and retrieve data for these purposes. Before reaching this stage, however, a decision has to be made on what will be inventoried and assessed and then this information translated into field instructions for collecting data. The level of detail required depends on whether the data will be used for local, regional or national purposes.

Experience gained in collecting and sorting data from many sources for RUN WILD indicates a need for systematic and uniform procedures for obtaining field data no matter what the level of use. Suggestions for collecting inventory and assessment data parallel those for developing a storage and retrieval system, but include the following:

1. A committee composed of regional representatives needs to be formed to oversee the development of a national inventory and assessment system.
2. Regional representatives should form a subcommittee to work with local biologists to collect field data.
3. A national vegetation classification system must be adopted as a base for inventorying wildlife habitat.
4. A special effort needs to be made to collect data on habitat requirements for nongame species.
5. Because of the large number of species that inhabit a given vegetation type, there needs to be a system developed for grouping species by common requirements.

In the Southwest, considerable progress has been made on the items listed above: a committee consisting of biologists from six state and federal agencies oversees the development of RUN WILD; there is a core of professionals that provide data; a hierarchical vegetation map exists for the area; research is being done by cooperators on nongame species; and a hierarchical system for grouping species by common requirements (species habitat profile) is being developed for RUN WILD.

Summary

Although RUN WILD was developed for wildlife habitat data within a specific geographic area, the basic system and approach can be used for other areas regardless of size. However, certain procedures must be followed in a given order before the computer programs in RUN WILD will work. Before adapting RUN WILD to a particular area or use, its features should be compared with other storage and retrieval systems.

RUN WILD is not a "black box," but is a practical working tool being used in Arizona and New Mexico to provide biologists with data for writing environmental impact statements and environmental analysis reports, evaluating land management practices to determine tradeoffs, developing habitat improvement projects, and providing recreationists with a list of animals they can expect to see when visiting selected areas in the Southwest. As new files and data are added, RUN WILD will better serve the needs of field biologists and land use planners.

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Efforts to Inventory Wildlife Habitat

Habitat Assessment for Breeding Bird Populations

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Introduction

Inasmuch as birds have evolved with other living organisms as components of ecosystems, they have adapted to the type of plant and animal associations found in each community. The importance of habitat configuration to breeding birds was discussed by Lack (1933, 1937), MacArthur and MacArthur (1961), Hilden (1965), and Wiens (1969). Wiens (1973) stated that the structure of the vegetation was ecologically important to birds in many ways, such as providing display perches, shelter, nest sites and foraging areas.

Traditional studies of avian habitat requirements have been conducted on individual species. Although data from such studies are valuable, current emphasis on ecosystem management means the habitat requirements of many species of birds must be considered as a group rather than on a species basis. An ecosystem approach to habitat inventory requires base data on avian habitat. Standardized techniques should be used to gather and store the data. These data can then be assimilated from many species-specific studies as well as from current community work, evaluated and presented to managers in a form useful for avian community management.

In this paper, I consider the types of avian habitat data available, how they are collected, and how they can be used for habitat management.

Avian Habitat Studies

Early investigators described the details of a given plant community and listed the birds found there. Thus, Twomey (1945) presented a list of birds, trees and other vegetation of an elm–maple forest. A discussion of nesting birds and the vegetation substrate (Beecher 1942) provided an excellent review of birds in several Illinois marsh and prairie habitats.

In some avian habitat studies, bird species assemblages have been compared with each plant successional sere (Adams 1908, Johnston and Odum 1956, Shugart and James 1973). A study in the northern part of the lower peninsula of Michigan (Kendeigh 1948) showed that plant communities have a nonuniform structure. Kendeigh found that the aspen-red maple forest contained two bird communities and the aspen-red pine an intermingling of three bird communities. This observation showed that bird communities did not always coincide with plant communities. Martin (1960) reported that certain species of birds in Algonquin Provincial Park, Ontario, overlapped into several plant community associations. Beals (1960) showed how different patterns in hemlock, pine, aspen, red oak, sugar maple and the percentage of understory contributed to differences in bird species richness in Minnesota.

A number of studies of breeding bird habitats have correlated population abundance with habitat. For example, Dwyer (1970) indicated that the physiognomy of the surrounding land, particularly the presence of marginal tall woody vegetation, appeared to limit the use of potholes by diving ducks in southwestern Manitoba. Jarvis and Harris (1971) showed the importance of grassy cover to nesting success of ducks on the Malheur National Wildlife Refuge in Oregon, and Frank and Woehler (1969) related habitat cover to pheasant production in Wisconsin.

Multivariate techniques have been useful in identifying important habitat variables for breeding birds. Sturman (1968), in a study of two chickadee species in Washington State, found that chickadee abundance was significantly correlated with canopy volume and upper-story vegetation. James (1971) combined data for a number of habitat variables to show how bird species responded to a combination of variables she referred to as the niche-gestalt. Anderson and Shugart (1974) analyzed the relationship of the spatially heterogeneous distribution of 28 habitat variables to the distribution of 28 breeding bird species in an eastern deciduous forest in Tennessee. Their study of the habitat relationships among this large number of species prevented a detailed study of the behavioral mechanisms of any single species. However, it did identify habitat variables that elicited measurable species response in terms of nonrandom species distribution on the habitat variables, and thus provided insight into the selection of variable groups that can be associated with a bird community.

MacArthur and MacArthur (1961) discussed the relationship between bird species diversity and foliage height diversity. Foliage height diversity was determined by measuring the percentage of vegetation in three to five layers. While other workers have questioned the results (Willson 1974), their interpretation did kindle interest in the relationship of bird species to vegetative structure. Later studies by Pearson (1971), Karr and Roth (1971) and Blondel et al. (1973) provided further evidence that bird species were associated with structural components of the vegetation.

Although features such as water, overlooks, vegetation on the ground and the shade of green (Svardson 1949) might influence the species of birds found in a plant community, habitat structure appears to be the major factor responsible for the complexity of associated bird communities. Thus, grouping of factors along with the total habitat size (Robbins 1979) must be the key concern for those managing habitat for breeding bird communities.

Habitat Sampling

Because birds find their habitat where all their requisite needs are satisfied, ethologists propose that clues or "sign stimuli" are received by the birds from the habitat (Lack 1933, 1937, Hilden 1965). One must include the components conveying information to birds as well as those supplying the intermediate needs of birds in the sample. That does not mean every feature must be sampled. It is possible to use indirect measurements by selecting features that convey information about other aspects of the habitat.

Classic habitat description, which involved listing dominant plant species, had two drawbacks (Wiens 1969). First, it ignored the fact that habitat responses of animals, especially birds, could be predicted on the basis of vegetation physiognomy. Second, it conveyed little information about the structural configuration of vegetation in an area, except to an experienced botanist.

To describe avian habitat, investigators started measuring the physiognomy of the habitat directly. Emlen (1956) used a symbolic description of habitat features, including vegetation height, canopy height, screening efficiency of the upper canopy, dispersion of plants and slope. By assigning one of several values to each variable, he was able to describe the area on the basis of the proportions of each. For example, nine categories of screening efficiency, or the shading characteristics of trees and shrubs were listed, ranging from sparse to very dense.

Wiens (1969) used a similar approach for grassland habitat. He symbolically described such features as vegetation form, stem arrangement, leaf shape and percent cover. Although both the Emlen and the Wiens approaches provided a great deal of information about the habitat, they were time-consuming. There were no clear results that show all of these features were necessary to describe avian habitat.

Less time-consuming methods of correlating bird species abundance with habitat features have been tested. MacArthur and Horn (1969) developed a technique to determine foliage profile by vertical measurements. A tripod with a plumb line calibrated in feet from the ground was set over a random point, and the number and position of leaves touching the plumb line was then recorded. A reflex camera with a telephoto lens was pointed vertically on top of the tripod. The camera was equipped with a gridded ground-glass screen with 16 small squares; vertical sighting enabled one to determine the number of squares in which canopy cover existed. These data were then used to estimate a habitat profile, which could be correlated with bird species richness as well as abundance.

Using a similar approach, Cyr (1977) mapped cover density of vegetation at different height intervals. In effect, he developed the silhouette of the vegetation profile to make a crude comparison of structure among plots. Both the Cyr and MacArthur methods so greatly reduced the number of habitat variables considered that correlation coefficients between habitat and individual bird species could not be developed. Although specific communities of birds could not be described by these methods, comparisons were made among the habitat structure of several different bird communities.

James and Shugart (1970) proposed a technique for sampling small plots of known size and extrapolating data from these plots to estimate the density and basal areas of an entire study site. Their method involved the random selection of 0.1-acre (0.04-ha) subplots in the bird census plots, the number of such subplots being determined by the diversity of habitat. Information collected included the species and diameter size class of trees, number of shrub stems, percent ground cover, canopy cover, and canopy height. The James and Shugart technique was adopted for the Audubon Breeding Bird Census. This form of data collection, which took about 30 minutes per plot, enabled one to construct matrices of habitat species association. Such a technique was relatively easy to learn but suffered from a lack of information on species patchiness among shrubs and ground-cover plants.

Avian Habitat Data Storage Systems

Just as there is as yet no uniform technique for collecting habitat data, there is no uniform procedure for storage of the data collected.

The Open Literature

Many ornithology, wildlife and ecology journals contain a wealth of quantitative information on avian habitat. When data are not listed in a paper, researchers often can get them from the author. Other important sources of data are the Masters and Ph.D. theses on bird community studies. Many of these contain much information in their appendices.

Breeding Bird Census

Every January, the results of Breeding Bird Censuses in different habitat types in the United States and Canada are published in *American Birds*. Areas of at least 15 acres (6 ha), preferably 25 acres (10 ha) or more, are selected by observers. Using the James and Shugart technique (1970), previously described, they survey randomly selected 0.1-acre (0.04-ha) points for habitat data. The results of these 0.1-acre (0.04-ha) point samples are summarized at the beginning of each census report in *American Birds*. Thus, the reader can compare bird species composition and density with the composition and structure of the vegetation in the different communities.

Breeding Bird Survey

The North American Breeding Bird Survey of the U.S. Fish and Wildlife Service and Canadian Wildlife Service has not up to this time collected data on the habitat of birds along the 24.5-mile (39.4-km) roadway routes. Currently the Service is testing means of collecting such data. This includes recording such information as the extent of contiguous woodland habitat, the percentage of each cover type near the road, whether the road is paved, the number of houses and the presence or absence of fence rows, wires and snags. Biologists are computing correlation coefficients with bird counts to determine which habitat factors are most effective in predicting the presence and abundance of each bird species (Robbins 1979).

Breeding Bird Atlas

The breeding bird atlas has become an important means of collecting data on bird populations in Europe. No large-scale atlas has been attempted in the United States; however, a number of states, including Illinois, Maine, Maryland, Massachusetts, Vermont and parts of California and Michigan, are using approximately 3.12-mile (5-km) grids (6 blocks per 7½-minute topographic map) to map the distribution of breeding birds. Although no specific habitat data have been gathered with avian population data used in the atlases, maps of bird distribution are ideal for relating bird distribution to other available habitat statistics. For example, the British published an Atlas of the Breeding Birds of Britain and Ireland (Sharrock 1976) and showed by overlay maps how bird distribution could be correlated with plant species distribution. A great potential exists in North America for relating bird atlas work to agricultural statistics, soil maps and Forest Service cover maps.

RUN WILD

The RUN WILD form, originally developed by the U.S. Forest Service and utilized by them in the West and by the U.S. Fish and Wildlife Service in the East, provides standardized data on breeding bird habitat. The distribution of breeding birds, information on the vegetation type or aquatic system in which the birds are found, their food habits, cover requirements and management practices for different levels of generalization are included in the computerized files.

National Assessment of Fish and Wildlife

The U.S. Forest Service, to comply with the Resource Planning Act, is gathering data on wildlife supply and demand that are being filed in Fort Collins, Colorado. This information can be correlated with habitat data they have obtained from state and private sources.

State Systems

Several states, including Maryland and Virginia, have incorporated data on wildlife in computer storage facilities available for land use planning. In Maryland, this 92-acre (37.3 ha) grid system is called MAGI. Biologists visit selected sites throughout the state and gather information on wildlife, including birds and their habitat, and place it into their systems for easy retrieval.

Other Data Storage Systems

The Audubon sponsored Colonial Bird Register at the Laboratory of Ornithology, Cornell University is a data storage system for information on waterbirds—their population status, colony size, and general habitat. Several other forms of habitat data banks exist in the U.S. Fish and Wildlife Service. The Wetland Inventory contains data on bird populations and their habitat. Ecological Services is preparing handbooks for different regions of the country. From their surveys of the literature and some field work, they gather data on different classifications of land use, plant and animal species, seral stages and the importance of food sources. These data, which are generally available in published form, can be used for wildlife surveys in a particular area (Flood et al. 1977).

The Migratory Bird and Habitat Research Laboratory is accumulating standardized numerical data from several study sites: the north central region of the United States and the deciduous forest of Maryland, Pennsylvania and West Virginia. These bird and habitat data are being placed in a computerized storage system so they can easily be retrieved when questions on habitat change are asked.

Data Evaluation

Habitat data collected in the field or retrieved from storage systems can be used to show correlations with all bird species in a community. It is particularly difficult to correlate habitat data with the occurrence of bird species that are more generalized in their distribution and habitat tolerance. I suggest that bird species closely associated with the habitat under study be utilized in determining management goals, because such species are most representative of a particular habitat. Thus, forest generalists, such as red-eyed vireos (*Vireo olivaceus*), would not be good indicators of mature deciduous forest, although they commonly nest there. Likewise, cardinals (*Cardinalis cardinalis*) would not characterize grassland habitat although they can be found in grassland borders. Edge species like the American woodcock (*Philohela minor*) also would not appear on a selected forest bird species list.

I have been studying the effects on wildlife and their habitat of the 1976 wildfire on the Seney National Wildlife Refuge (in the Upper Peninsula of Michigan), which swept through 100 square miles (260 km²) of mixed forest and bog habitat (Anderson 1979). I am also evaluating habitat requirements of birds in the mature deciduous forest of western Maryland, Pennsylvania and West Virginia. In both studies, habitat data are being collected on 0.1-acre (0.04-ha) plots by the James and Shugart (1970) technique.

A group of birds representative of the mixed forest in Michigan's upper peninsula and the deciduous forest in the Maryland, Pennsylvania and West Virginia areas were used to examine the habitat requirements of the birds in those communities (Tables 1 and 2). Several statistical techniques were examined to show how key habitat factors associated with these bird groups could be determined. Given the data, managers can then direct their efforts to maintaining the habitat of the selected species. Presumably the more generalist species can also use the area for breeding.

Stepwise Multiple Regression

Using the abundance of bird species as dependent variables and the habitat measurements as independent variables, one can establish regression equations to indicate which of the habitat variables sampled can best be used to predict the abundance of bird species (Sturman 1968, Thomas et al. 1977, Robbins 1978).

Stepwise multiple regression (Barr et al. 1976) operates so that variables are added into the regression equation in the order in which they increase the multiple correlation coefficients. The variable that reduces the residual variation about the least square regression line the most, is added first; the variable that most reduces the variation when considered with the first variable is then added second; the third variable considered in conjunction with the first two which most reduces the variation is added next; and so on. Habitat variables are entered successively into the equation until none remain that significantly reduce the variation around the least squares line. Thus a different number of variables acting together are significantly correlated with each bird species.

An examination of the significant variables associated with each bird species sampled on the Seney National Wildlife Refuge habitat reveals that no one habitat variable is truly dominant (Table 3). When only selected bird species are considered, three factors—the number of seedlings, the number of trees and canopy depth—are associated with more species than the other (Table 1). These results indicate that a mixed size class, subclimax forest with a few openings is important to this selected group of six bird species. Frequency of snags is not correlated with this group and canopy closure appears as only the fifth (and last) variable for one species, white-throated sparrows (*Zonotrichia albicollis*).

In the Maryland, Pennsylvania and West Virginia area, when the regression analysis is run using all bird species, the variable of stand area is associated with

Table 1. Order in which habitat variables were entered into stepwise discriminant function (D under each variable) and stepwise regression equation (S under each variable) for selected bird species in forest of Seney National Wildlife Refuge.

	Habitat variables																	
	Trees 24–44 cm DBH		Trees < 24 cm DBH		Shrubs		Number of saplings per hectare		Number of seedlings per hectare		Number of snags per hectare		Percent of plot burned		Percent canopy closure		Mean canopy depth	
Bird species	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S
Red-breasted nuthatch (RBNU) *Sitta canadensis*			1	1			2	2										
Hermit thrush (HETH) *Catharus guttata*						3				1		2					1	
Cape May warbler (CMWA) *Dendroica tigrina*			2	1					1	2								
Yellow-rumped warbler (MYWA) *Dendroica coronata*	3	3							1	1							2	2
Ovenbird (OVEN) *Seiurus aurocapillus*	3	3							2	2							1	1
White-throated sparrow (WTSP) *Zonotrichia albicollis*				4		2	1			1			2	3		5		

Table 2. Order in which habitat variables were entered into stepwise discriminant function (D under each variable) and stepwise regression equation (S under each variable) for selected bird species in deciduous forests of Maryland, Pennsylvania and West Virginia.

Bird species	Habitat variables																													
	Stand age		Stand area		Slope		Distance to edge		Number of tree species		Shrub height		Percent ground cover		Canopy height		Percent canopy closure		Canopy depth		Shrub stems per hectare		Trees 8–15 cm DBH		Trees 16–38 cm DBH		Trees > 39 cm DBH		Percent log cover	
	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S
Tufted titmouse (ETTI)																														
Parus bicolor								6					1	2	2	1				3		4				5				
White-breasted nuthatch (WBNU)																														
Sitta carolinensis							3	5	2	3			7		6		5				4	2	1	1						4
Wood thrush (WOTH)																														
Hylocichla mustelina								1						3				4		2							1			
Worm-eating warbler (WEWA)																														
Helmitheros vermivorus			1	1	2	2													4	4					3	3				
Ovenbird (OVEN)																														
Seiurus aurocapillus	3	2					1	1												5			2			4				3
Kentucky warbler (KEWA)																														
Oporornis formosus		4			1	3		5		2			3				2	1	4			6								
Hooded warbler (HOWA)																														
Wilsonia citrina					1													1		3				2						
American redstart (AMRE)																														
Setophaga ruticilla			1	2												3				4							2			1
Scarlet tanager (SCTA)																														
Piranga olivacea				1							2		3								1									

Table 3. Number of times habitat variables are significant in the stepwise regression equations and stepwise discriminant functions for all bird species on plots on the Seney National Wildlife Refuge.

Habitat variables	Regression	Discriminant function
Trees 24–44 cm DBH	14	10
Trees < 24 cm DBH	9	8
Shrubs	16	13
Number of saplings per hectare	9	11
Number of seedlings per hectare	24	16
Number of snags per hectare	13	11
Percent of plot burned	18	14
Percent canopy closure	9	16
Mean canopy depth	10	10

the most bird species. Tree size classes do not appear important to many species (Table 4). When only selected bird species are considered, stand area is one of eight variables that appear important. The larger stands with closed canopies are correlated with this group of birds associated with the forest interior.

Discriminant Function Analysis

Whereas stepwise multiple regression deals with the interdependence of variables, and each variable is dependent on how much it, in combination with other variables, reduces residual variation around the regression line, correlations in discriminant function analysis are established between habitat variables, and in-

Table 4. Number of times habitat variables are significant for the stepwise regression equations and stepwise discriminant functions for all bird species on plots in deciduous forests of Maryland, Pennsylvania and West Virginia.

Habitat variables	Regression	Discriminant function
Stand age	13	9
Stand area	24	21
Slope	12	12
Distance to edge	26	9
Number of tree species	10	9
Shrub height	15	9
Percent ground cover	19	15
Canopy height	20	12
Percent canopy closure	19	9
Canopy depth	13	17
Snags per hectare	2	5
Shrub stems per hectare	11	15
Trees 8–15 cm DBH	4	5
Trees 16–38 cm DBH	3	8
Trees > 39 cm DBH	3	7
Percent log cover	9	4

dependent discriminant functions are generally based on the presence or absence of bird species. Anderson and Shugart (1974), who used discriminant function analysis to identify key habitat factors in an eastern deciduous forest, found that generalist bird species are associated with many habitat variables, whereas selected species of the forest are correlated with only a few.

When the bird species on the Seney National Wildlife Refuge plots are considered, seedlings, degree of burn, shrubs, and tree size class are correlated with the largest number of bird species (Table 3). Selected species are also correlated with seedlings; however, canopy depth is also important to a number of species (Table 1). Taking these data together with results from the regression, a composite habitat description can be established for the selected species consisting of a subclimax forest with small openings. Neither degree of burn nor frequency of snags is important to these species.

In the deciduous forests of Maryland, Pennsylvania and West Virginia, distance to the edge, stand size, canopy height, canopy cover, ground cover and shrub height all appear important to the total bird community (Table 4). By contrast, the selected species are associated most commonly with ground cover and slope (Table 2). Thus, in conjunction with the regression, an extensive forest interior with a high canopy and occasional openings emerges as a description of the bird habitat.

Factor Analysis

Factor analysis is a statistical technique that can be used to reduce several habitat variables in a multidimensional space. It is similar to principal component analysis; however, principal component analysis scales the variables so that the sum of the squares for the element in each vector equals one. When this is done, the associated eigenvalue (characteristic root) is interpreted as the variance along the principal component axis. Factors in factor analysis are scaled so that coefficients are the correlation coefficients with the original measurement. Factors can then be rotated to make them more interpretable biologically.

On the Seney Wildlife Refuge, all the habitat data gathered were used to present an ordination of the plots, which was constructed by using the principal axis factor analysis of the habitat variables with a varimax rotation (Overall and Klett 1972, Greig-Smith 1974, and Barr et al. 1976).

Three factors are useful in separating burned and unburned habitat on the Seney Refuge. The first (Table 5) represents a mature forest with high habitat factor loadings for number of trees, percent canopy closure and mean canopy depth; the second represents the effect of the burn and has a high positive correlation with the number of snags and the number of seedlings, and the third represents the shrub component of the vegetation.

The factor scores for each bird species are determined on the basis of the weighted variables of the plot on which these species are found (Table 5). Selected bird species are then added to plots of the three habitat factors by using the factor scores (Figure 1). In this situation, all the selected species cluster around the score for the center of the plot. To demonstrate that the factor analysis does separate bird species, I added the black-backed three-toed woodpecker (*Picoides arcticus*) to show a species common on burned plots with standing snags.

Table 5. Habitat factor loadings (correlation coefficients with observed habitat variables) for the principal axis factor analysis with a varimax rotation on Seney National Wildlife Refuge and mean factor scores for selected bird species.

Habitat variables	Factor 1	Factor 2	Factor 3
Trees 24–44 cm DBH	0.74	−0.01	−0.37
Trees < 24 cm DBH	0.82	−0.08	0.15
Shrubs	−0.17	−0.07	0.84
Number of saplings per hectare	0.57	0.09	0.64
Number of seedlings per hectare	0.01	0.86	0.13
Number of snags per hectare	−0.03	0.88	−0.14
Percent of plot burned	−0.60	0.55	−0.11
Percent canopy closure	0.95	−0.04	0.01
Mean canopy depth	0.94	0.14	−0.08
Percent cover—grasses & sedges	−0.59	−0.60	−0.02
Bird species			
Black-backed 3-toed wookpecker	−0.18	2.35	0.20
Red-breasted nuthatch	1.17	−0.18	−0.29
Hermit thrush	0.47	0.27	−0.02
Cape May warbler	1.15	0.19	0.33
Yellow-rumped warbler	0.46	0.11	0.28
Ovenbird	0.86	0.14	−0.09
White-throated sparrow	−0.13	0.48	0.33

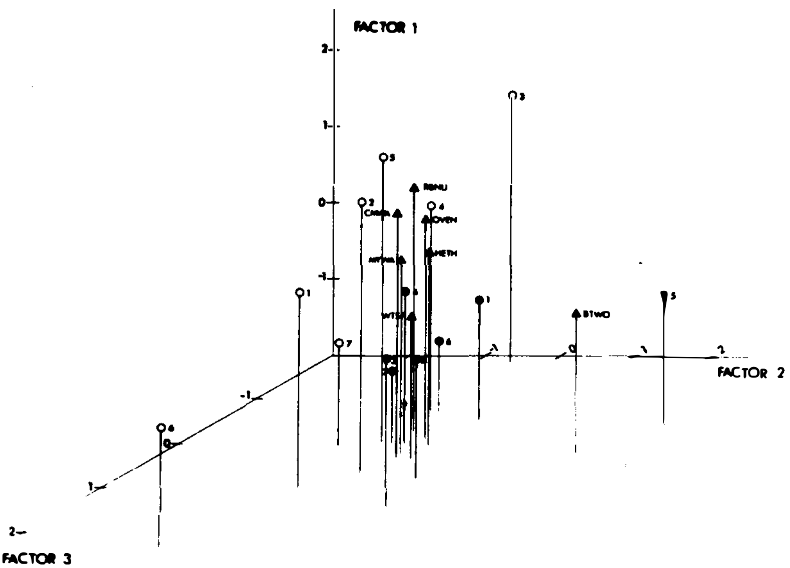

Figure 1. Ordination of plots and selected bird species in space of habitat factors formed by principal axis factor analysis with a varimax rotation for Seney Wildlife Refuge. Plots are numbered (black—burned, white—unburned). Black-backed three-toed woodpecker (BTWO); other species codes in Table 1.

Table 6. Habitat factor loadings (correlation coefficients with observed habitat variables) for the principal axis factor analysis with a varimax rotation in Maryland, Pennsylvania and West Virginia and mean factor scores for selected bird species.

Habitat variables	Factor 1	Factor 2	Factor 3
Stand age	0.57	0.21	0.13
Stand area	0.28	0.19	0.17
Slope	−0.23	−0.20	−0.13
Distance to edge	0.07	−0.17	0.53
Number of tree species	0.12	0.72	0.15
Shrub height	0.24	0.46	−0.17
Percent ground cover	−0.01	−0.61	0.10
Canopy height	0.72	0.25	0.10
Percent canopy closure	0.15	0.73	0.19
Canopy depth	0.59	0.03	0.50
Snags per hectare	0.00	0.12	0.60
Shrub stems per hectare	−0.02	0.01	−0.64
Trees 8–15 cm DBH	−0.58	0.53	0.18
Trees 16–38 cm DBH	0.09	0.39	0.67
Trees > 39 cm DBH	0.74	−0.10	−0.30
Bird species			
Tufted titmouse	0.09	−0.10	0.09
White-breasted nuthatch	0.43	−0.25	0.23
Brown thrasher	−0.60	−0.99	−0.04
Wood thrush	0.07	0.06	−0.01
Worm-eating warbler	0.07	0.24	0.20
Ovenbird	−0.02	0.16	0.23
Kentucky warbler	0.22	0.04	0.25
Hooded warbler	0.29	0.05	0.02
American redstart	0.14	0.20	0.36
Scarlet tanager	0.03	0.03	0.03

Table 6 shows a similar factor analysis for the Maryland, Pennsylvania and West Virginia data. Here, the first of these factors represents a deciduous forest, as tree height and canopy height are highly correlated with this vector; the second relates to canopy closure and the number of trees, thus representing a less mature forest; and the third is correlated with medium sized trees, snags and canopy depth.

When selected bird species are added to the figure based on the factor score for each species (Table 6), a three-dimensional plot results on which the bird species are clustered (Figure 2). Addition of the brown thrasher (*Toxostoma rufum*) to the plots shows that this species, found in heavy brush near the edge, differs from the cluster of forest species.

Both regression analysis and discriminant function analysis help select variables useful in describing bird species habitat. The fact of independence of the discriminant function variables from one another enables the examination of each variable separately. Discriminant function also allows the biologist to examine groups of habitats where species are present or absent. Factor analysis can be used to

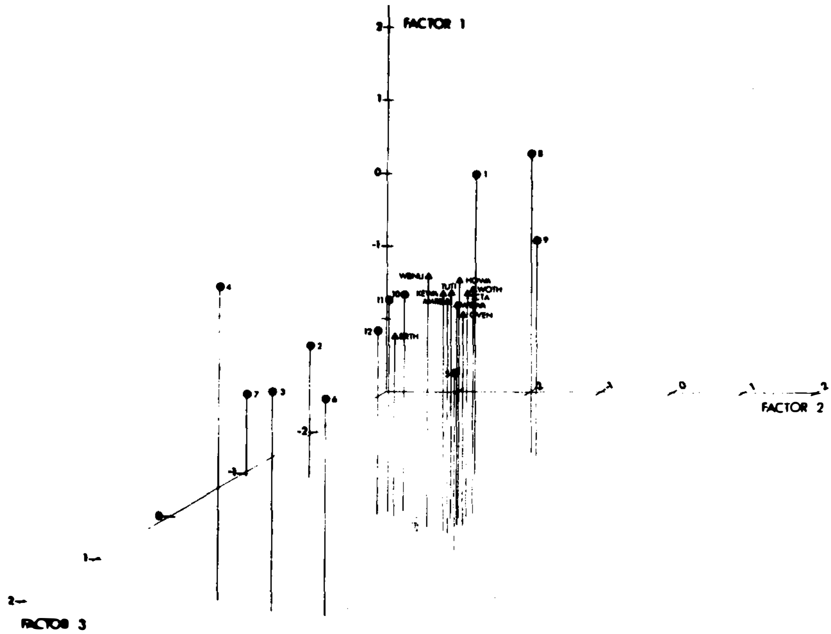

Figure 2. Ordination of plots and selected bird species in space of habitat factors formed by principal axis factor analysis with a varimax rotation for deciduous forests of Maryland, Pennsylvania and West Virginia. Plots are numbered. Brown thrasher (BRTH); other species codes in Table 2.

verify habitat associations for groups of bird species and to predict bird population changes due to habitat alteration.

Where Do We Go from Here?

One of the biggest problems plaguing land managers interested in breeding bird habitat is the lack of data standardization. Although there are many sources of data, each one uses slightly different techniques, making it difficult to develop correlations between birds and their habitats.

Carefully planned research on habitat variables associated with bird species and bird communities must be conducted and verified. Bird habitat should be classified and representative bird species be established for each. We need to move to more explicit community studies. I have illustrated several techniques to identify community habitat components required by selected bird species. Other techniques, like canonical analysis which can be used to determine bird habitat relationships, need to be tested.

By determining bird community requirements biologists can develop standardized habitat collection and storage techniques. If the data in storage systems are easily accessible, they can then be used by researchers to determine the impact of habitat alteration on bird communities and by planners and managers for habitat enhancement.

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Maryland Wildlife Resources Information Retrieval System

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Introduction

Strategic wildlife management planning involves the development of measurable objectives which guide the proper allocation of available resources to solve wildlife resource and recreational use oportunity problems. These objectives are based on information concerning present and future supplies of and demand for wildlife resources.

Previously, the development of strategic wildlife management objectives for Maryland was constrained by the lack of information available for decision makers concerning habitat supplies and wildlife use opportunities. Existing habitat inventory and wildlife distribution sources in Maryland have too often proved limited in scope, accuracy, and relationship to effectively assist wildlife managers in administering and developing programs. To remedy this situation, the Maryland Department of Natural Resources, in cooperation with the Department of State Planning, is developing a wildlife information retrieval system which employs geographically-referenced habitat variables and wildlife sightings that can be graphically presented on computer maps both independently or in overlayed combinations.

This presentation describes the objectives of the system, the information base being utilized, the application of the system to the decision-making process, and the events that led to the system's development.

System Objectives

The Maryland Wildlife Administration (MWA) is a member agency of the Department of Natural Resources, a cabinet level department under the State Executive. The mission of the Administration is to oversee and manage the wildlife resources of the state in conjunction with other resource management agencies in the Department. The role of the Wildlife Administration over the last six years has concentrated on managing the species and the agency-controlled lands in a more planned and coordinated manner. The Wildlife Information Retrieval System will provide a continuing mechanism to meet the following objectives:

[1]Prepared while at the Maryland Department of State Planning, Baltimore

1. Identify critical wildlife habitats throughout the state. Identification of these areas will be determined under three category headings:
   a. Habitat bases necessary for maintenance and expansion of endangered species' populations.
   b. Habitat bases necessary for maintaining the integrity of Maryland's recognized wildlife species and for supporting populations which satisfy recreation demands.
   c. Habitats which support a comparatively high diversity of wildlife species within each respective physiographic region.
2. Geographically delineate known areas of wildlife species' distribution, the present potential range available, and the future predicted range status for selected Maryland wildlife species. (Projected habitat supply estimates will be determined at least 15 years beyond the project date and will emphasize the effects of proposed urban development.)

Information Base

Maryland Automated Geographic Information (MAGI) System

The Maryland Wildlife Resources Information Retrieval System is an outgrowth of, and will function within, a parent system called MAGI (Maryland Automated Geographic Information System) developed and maintained by the Maryland Department of State Planning. This Department established the Maryland Automated Geographic Information (MAGI) System in 1973 to serve as the primary data base for the preparation of a state land use plan. The need to identify, organize, store, retrieve, manipulate and analyze data on a geographic basis created the impetus to develop an automated and geographic information system.

Initial MAGI System design and implementation was biased by three factors. The first was the need to develop a system to support generalized state land use planning within a relatively short start-up time (18 months). The second was the availability and magnitude of funding and the potential for continuity in funding. The third factor was a desire to develop flexibility in both the software and the data base to accommodate other potential users of a statewide geographic information system.

Initial Data Base and Data Entry

MAGI is a grid based system. The State Plane Coordinate System was chosen as the basic referencing system for several reasons: (1) the entire state is included in one zone, the majority of previously published or collected data were compiled on maps of Lambert Conformal Conic projection—the same used for the State Plane Coordinate System. (2) The MAGI grid dimensions of 2,000 feet by 2,000 feet (609.7 m by 609.7 m) enclose an area of 91.8 acres (37.16 ha). The statewide data base contains approximately 88,000 cells. The choice of this statewide grid size represented a compromise among costs of data entry (funding availability at the time of data base construction), scale of the majority of existing mapped data, and a perceived level of generality/specifity necessary to carry out statewide or regional studies.

Two decisions were made. The first was to insure that the software was capable of handling smaller grid sizes that could eventually be nested and aggregated to the initial grid. A grid cell of 4.57 acres (1.6 ha) with the dimension of 400 feet by 500 feet (121.6 m by 152.4 m) has subsequently been developed for smaller study areas.

Secondly, a data entry technique of recording more than one level of detail for each data type (or variable) per cell was used. Typically, the most dominant element (i.e. a land use, or soil type) would be encoded for each cell. The adaptation utilized expanded the encoding scheme to include the secondary, or second most dominant element in the cell. For finely textured data, this procedure was carried out to three or more levels. The ordering of Primary, Secondary, and Tertiary occurrence was accomplished visually and the relationship was a qualitative one isolated to each cell independently. This technique, though not providing greater locational or quantitative specificity within a cell, did improve the potential for accounting for the texture or heterogeneity of data. Recently, data encoded for more than one level of detail per cell per variable has been augmented by an approximation of acreage for each level of occurrence. Figure 1 includes a summary of the variables included in the statewide data base and the detail encoded for each cell.

Hardware

The System was implemented at the University of Maryland's Computer Science Center (CSC) and tied to the Department's Baltimore office by remote terminals. Several reasons supported this decision. First, the Univac 1108 at the University of Maryland equalled or exceeded the capabilities and capacities of other state facilities (though they substantially exceeded the needs of the MAGI System). Second, the CSC was set up as a user oriented system compared to other systems which were substantially dedicated to agency programs (e.g. motor vehicle registration, comptroller's accounting). Third, technical consultants were available on a cost-reimbursable basis on an as-and when-needed basis. This provision permits the Department to operate the System without a systems analyst or other individual with computer expertise on the staff.

Plotters, keypunch, cathode ray tubes (CRTs) and other associated hardware are available through the University and other state agencies on a similar basis. In effect, total hardware investments are and continue to be limited to office equipment, map and output files, and leased telecommunication terminals.

Software

The MAGI System software package consists of a set of interrelated FORTRAN programs. The software was initially developed by Environmental Systems Research Institute (ESRI) of Redlands California for the Department. Subsequently, the routines were modified and expanded by the Department staff and staff of the University of Maryland's Computer Science Center under contract to the Department. Many of the modifications were directed toward improving remote interfaces with the software and increasing the efficiencies of data handling and manipulation.

VARIABLE	TYPE OF DATA DISTRIBUTION	LEVEL OF* OCCURRENCE ENCODED
PHYSICAL DATA VARIABLES:		
NATURAL SOIL GROUPS	Polygon	P,S,T
TOPOGRAPHIC SLOPE	Polygon	P,S
ENGINEERING GEOLOGY	Polygon	P,S
SURFICIAL HYDROLOGY (WATER QUALITY)	Polygon	P
MINERAL RESOURCES	Polygon,Point	P
VEGETATION COVER TYPES	Polygon	P,S
UNIQUE NATURAL FEATURES AND SCENIC AREAS	Polygon,Point Line	P,S
ENDANGERED SPECIES	Polygon,Point	P,S
BAY BATHYMETRY	Point	P
CULTURAL DATA VARIABLES:		
1970 LAND USE	Polygon	P,S
1973 LAND USE	Polygon	P,S,T
1978 LAND USE	Polygon	P,S,T + est. acreage
1973 COUNTY SEWER/WATER SERVICE AREAS	Polygon	P
1976 COUNTY SEWER/WATER SERVICE AREAS	Polygon	P
TRANSPORTATION FACILITIES (NON-HIGHWAY)	Line,Polygon, Point	P,S
1980 COUNTY COMPREHENSIVE PLANS	Polygon	P,S,T
PUBLIC PROPERTIES	Polygon,Point	P,S
HISTORIC SITES	Point,Polygon	P,S,T
HIGHWAYS	Line,Point	P,S
OUTDOOR RECREATION/OPEN SPACE	Polygon,Point, Line	P
AREAL DATA VARIABLES:		
COUNTY	Polygon	P
WATERSHED (STREAM SEGMENT)	Polygon	P
ELECTION DISTRICT	Polygon	P
CENSUS TRACT/MINOR CIVIL DIVISION (MCD)	Polygon	P
CELL IDENTIFIED (ROW/ COLUMN COORDINATE)	N/A	N/A
NEW SYSTEM VARIABLES:		
EDGE EFFECT	Polygon	P
STREAM CLASSIFICATION	Polygon,Line	P,S,T,Q
ARCHAEOLOGICAL SITES	Point,Polygon	P,S,T,Q

* P - Primary T - Tertiary
S - Secondary Q - Quarternary

Figure 1. Current MAGI System state-wide data variables.

FILGEN	- File generation; converts data from card images to a single variable file arranged in a matrix of rows and columns.
GRID	- used to display, or map, single variable files or to retrieve, manipulate, and display data, in map form, based on a user supplied FORTRAN algorithm (SUBROUTINE MODEL).
MAPMERGE	- used to assemble single variable files into multi-variable files.
CELLUPDAT	- used to update or correct, on a cell by cell basis, either single or multi-variable files. - a variation is used to generate a file of update cards where there is a block of cells (usually 100 or more) that require an update or when data to be updated have some numerical pattern.
ADDON	- used to append a blank (zero) file to a multi-variable file. Data can be entered by CELLUPDAT or MAPMERGE.
CHANGE-ALL	- used to modify, update, or reclassify data when the change is consistent throughout a variable.
SEARCH	- used to either identify the minimum distance to a grid cell with a particular data value or to identify the frequency of a particular data value within a given radius of each grid cell.
WINDOW	- used to separate a portion of a multi-variable file for a specified area from a larger file.
LIST	- used to display the data values for each variable (or pre-selected variables) for each cell. - frequently used in conjunction with WINDOW.
VARLIST	- used to generate tabular summaries of single variable files or output files from GRID. - requires as input both the file of data to be summarized and an areal file by which the tabulations are to be made (e.g. election district, watershed).

Figure 2. MAGI software elements

The software serves two functions: (1) the creation and maintenance of the System's data base, and (2) the retrieval, manipulation and display of System data. Multi-variable analysis requires the input of several variables and assigns them to specified map output levels through the use of FORTRAN algorithms. The utility of this capability is described in conjunction with specific applications later in this paper. Figure 2 lists and sketches the functions of each program.

Data Display

The standard output product of the MAGI System is a line printer map at several scales. Though program execution is accomplished remotely, output maps are generally produced on high speed line printers at the University. The output is then delivered by an existing courier system between College Park and Baltimore on a daily basis for a nominal fee. The map products are typical of line printer products with a nominal capacity of 75 symbols or grey tones for output discrimination utilizing overstrike capabilities. MAGI output maps can also be interfaced with CalComp software and the map output plotted on standard drum or flat bed electromechanical plotters.

High quality black and white or color prints, or color transparencies can be generated from output files using a Dicomed image recorder. Though more costly than the two previous techniques, the product is an excellent media for reproduction- and publication-bound maps.

Wildlife Applications

As stated previously, the preparation of the state land use plan was the impetus for developing MAGI. Soon after its implementation, the data base was extensively used to support several executive and legislative studies concerning the preservation of prime agricultural land. As experience and confidence grew with the use of the MAGI System, the Department of State Planning began to promote its use by federal, state and local government agencies. The Maryland Wildlife Administration was the first such state agency to realize the potential.

Those first efforts were simple applications, but current plans may culminate in one of the most comprehensive wildlife management information systems undertaken nationally.

Wild Turkey Habitat

In 1975, the Maryland Wildlife Administration (MWA) began plans for recolonizing wild turkey (*Meleagris gallapavo*)—the bird Ben Franklin supported for the national emblem—in celebration of the Bicentennial. At the request of the Maryland Wildlife Administration, MAGI was used to classify and quantify existing and potential ranges of wild turkey in selected portions of the state. Criteria such as present location of turkey populations, turkey habitat requirements, and human activity constraints were used to determine levels of potential wild turkey habitation. To evaluate the criteria and feasibility of the study, four counties were chosen as test areas. Figure 3 illustrates a turkey habitat map for one of these counties. Field checks by MWA personnel confirmed that the "modelled" areas were indeed suitable for the release program. The entire state was then evaluated for the turkey release program.

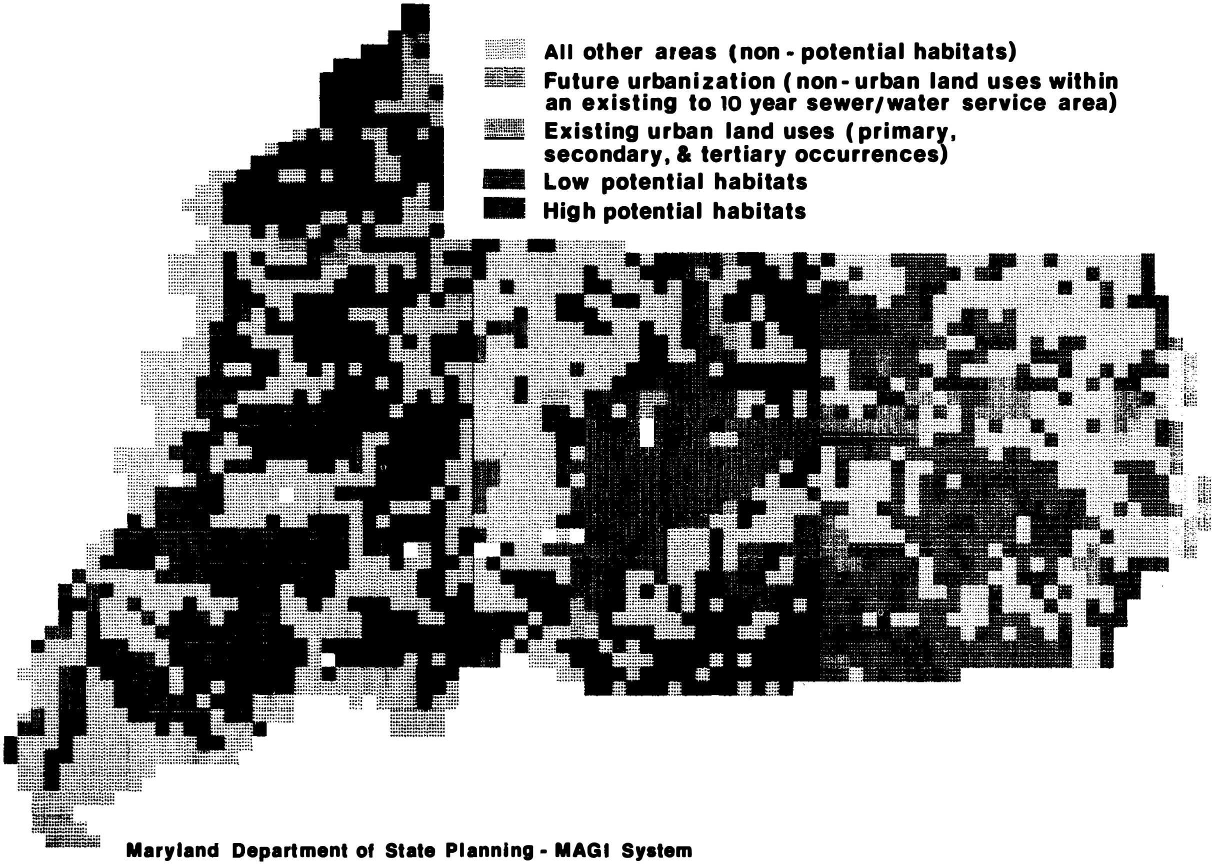

Figure 3. Potential for wild turkey introductions.

This small success led to a series of applications for the Maryland Wildlife Administration. A continued interest in the management practices of a sister agency, Maryland Forest Service, led the MWA to undertake a more thorough examination of the turkey habitat of Green Ridge State Forest encompassing some 27,000 acres (10,900 ha). The statewide data base was augmented with refined vegetation survey data including stand size/class data for this special study area which was WINDOWed from the state file. Specific turkey habitat zones (12,000 acres, 4,800 ha) were identified as possessing sufficiently high quality turkey habitat to justify certain forest management practices on the part of the Maryland Forest Service. As the management program develops, a detailed data base for the habitat zones (4.57 acre or 22.95 acre) will be established.

Delmarva Fox Squirrel: An Endangered Species

Utilization of the MAGI system proved to be a valuable component in the review phase of environmental impact assessments. In preparing an agency impact assessment of a proposed fossil-fuel power plant on Maryland's Eastern Shore, the MAGI system was employed to determine the plant's impact on the potential range of the Delmarva fox squirrel (*Sciurus niger cinereus*). Information on habitat preferences of the endangered species is scarce. The conventional procedure of conducting a literature search provided insufficient results to base a selection of MAGI habitat data variables. The MAGI system was, therefore, programmed to provide listings of habitat variables found in cells where Delmarva fox squirrel observations had been recorded. The variable listings in these cells were then analyzed to determine which variables proved significant in their rate of occurrence. Combinations of variables involving certain natural soils groups, forest cover types, and cultural land uses, were determined to be significant components of Delmarva fox squirrel habitat based on this process. The MAGI system was programmed to produce a map showing the geographic distribution of those habitat conditions. (Refer to Figure 4.)

Comparison of the potential range map with the map of land use changes expected from the power plant placement allowed for a quantitative expression of its impact on the planned recovery efforts of the Delmarva fox squirrel population.

These and several other applications have led the Maryland Wildlife Administration to develop a Wildlife Resources Information Retrieval System as a component of the MAGI System.

Wildlife Resources Information Retrieval System

The keys to implementing such a wildlife information system are the two primary components:

1. Establishing a data bank sufficient in detail to identify habitat types, and
2. Documenting and automating previous and future wildlife sighting data.

The discussion that follows provides specific discussions on the work undertaken to develop each of these components.

Wildlife Habitat Data Bank

The MAGI data base (Figure 1) used in preparing the state land use plan was evaluated to determine if habitat information required to satisfy the wildlife infor-

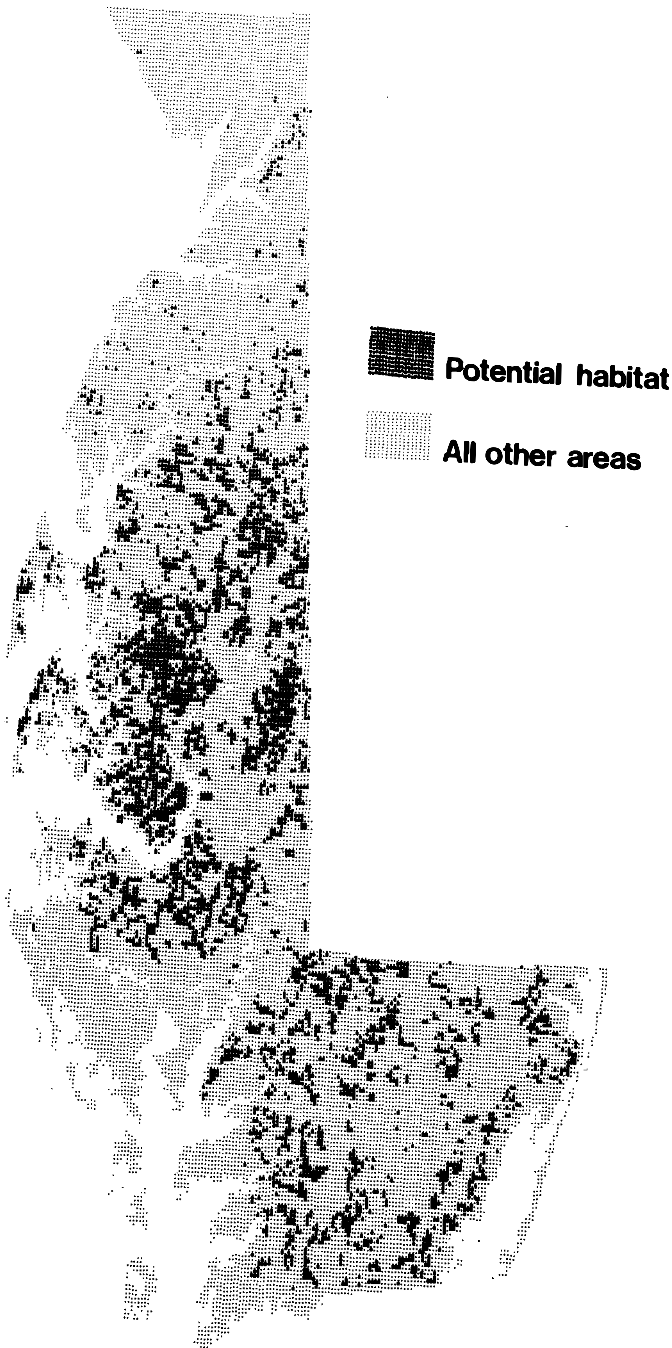

Figure 4. Delmarva fox squirrel habitat.

mation system objectives could be derived. Habitat variable classes were needed in a format compatible with descriptive language used in habitat accounts found in literature citations for individual species. The classification scheme also needed to exist in sufficient detail to be responsive to habitat-specific needs of selected wildlife species. The evaluation showed that several of the MAGI System's variables required further refinement for application towards analyzing wildlife habitat supplies. Three variables were identified for refinement: surface hydrology, vegetative edge, and wetlands.

A refined surface hydrology variable was added to the data base. The source was a series of quadrangle maps which had been previously annotated using the Van Deusen stream classification. This system accounts for the stream class, width, depth, temperature regime, bottom characteristics, flow and several qualitative characteristics. It also includes such features as canals, ditches and springs.

The evaluation also showed that the minimum size retained for land cover data (10 acres/4 ha) precluded incorporation of important habitat elements within agricultural, upland brush, and forested areas. The relationship between wildlife populations and the amount of edge effect existing along forest margins and vegetated strips is well documented. Many features such as forest openings, vegetated strips, and hedgerows occupied less acreage than specified for management unit classification. The presence of these features within larger land classes are highly influential, though, on resident wildlife populations and were considered necessary to the data bank.

The MAGI land cover variable units, identifying forest, upland brush, and agriculture use categories, were identified from enlargements of high-altitude color infrared photographs (1 inch = 1 mile). In order to develop an edge occurrence variable, the black and white enlargements were laid on a light table and overlayed with a blank mylar sheet. Reference coordinate grids were drawn on the blank mylar for orientation purposes. The photo was then examined through the mylar for the presence of woods margins and vegetated strips. The outlines of these features were penciled on the blank mylar—one color for woods margins (within forest land use units) and a second for vegetated strips (within agricultural and upland brush land use units). Interpretation was aided by projecting the original color infrared photograph on the wall in front of the interpreter.

The mylars with penciled entries were then overlayed with a grid-cell mylar. Each 90-acre (36.5 ha) cell was examined as to the amount of linear edge existing in either or both variables and encoded as follows:

1. No linear edge.
2. > 0 but < 2000 linear feet (609.6 m) of edge.
3. > 2000 linear feet of edge.

A third variable identifying the location and type of coastal wetlands data was prepared using data collected by the Coastal Zone Administration's Tidal Wetlands Study. This classification scheme will allow for future refinement of coastal wetland classes by vegetative associations within the information system.

Wildlife Sighting Records

Records of wildlife sightings documented in a site-specific context are quite important to the overall determination of known and potential ranges of a given species. The distribution of wildlife in Maryland is not presently addressed comprehensively in any single source, but rather in a series of works emphasizing specific animal groups. Each of these sources defines the range for their respective species group in terms of its occurrence within a physiographic region or political boundary within the state. These studies can and will serve as an historical cross-reference for generalized statements about wildlife distribution in Maryland. However, the refinement of the range of distribution for selected species required a wildlife sighting record storage and retrieval capability compatible with the geographically-referenced habitat data files.

Past wildlife sighting records from many sources were examined to see if location descriptions could be reliably assigned reference grid coordinates. A record collection was eventually developed which listed the wildlife species observed, the date of observation, the grid coordinates of the sighting, and a reference to the source of the observation. This collection is presently being programmed into the MAGI System to be used in support of species' range analysis.

Application

The delineation of available habitat for a given species through the Maryland Wildlife Resources Information Retrieval System is dependent on the ability of the investigator to define the species' habitat preferences. Once a species habitat information account has been prepared, the habitat variables within the system can be reviewed to determine what combination of data variables best expresses the habitat needs identified in the literature summary. The system is then programmed to produce a computer map which shows the 90-acre (36.5-ha) cells that offer the selected habitat variable combinations.

An example of this process was previously shown in Figure 3. This map illustrates the potential range for the Eastern wild turkey in one of Maryland's counties. The map product was preceded by a selection of encoded habitat variables which provided a "best-fit" situation to the investigator's habitat summary. Once the turkey sighting records are overlayed with the information on available habitat, the map can offer insight as to which extirpated areas could be used as potential transplant sites.

The Maryland Wildlife Resources Information Retrieval System will provide a sizable contribution to conserving wildlife resources in the state by providing information on critical habitats to local planning jurisdictions. As critical habitat bases are defined, they can be incorporated into local planning and zoning schemes in order to minimize the adverse impacts of future development activities in this rapidly urbanizing state. Information of this nature will assist wildlife managers in identifying current and anticipated issues and problems facing the wildlife resource and recreational concerns. The intent is to describe and map available habitat for each game and nongame species present in Maryland. This data will be augmented by observations and the habitat maps and species distributions modified by successive iterations through the process.

The information made available through this system on habitat availability, coupled with resource user demand information, provides a basis for determining management objectives for both near future and long-range wildlife recreational programs.

Efforts to Inventory Wildlife Habitat

Progress Toward a Terrestrial Ecosystem Monitoring Program for the U.S. Space Shuttle Program

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Introduction

The National Aeronautics and Space Administration (NASA) anticipates that the nation's space shuttle will be launched and landed at the Kennedy Space Center (KSC) over the next two decades (Malkin 1978). Potential environmental effects of the space shuttle program are outlined in the Environmental Impact Statement (NASA 1978). Ground level and tropospheric effects include habitat loss associated with the construction of permanent facilities, such as the orbital landing strip, and short- and long-term effects from shuttle launches. These latter effects include noise pollution and the possibility of acidification of the landscapes by solid rocket motor exhaust emissions.

The Kennedy Space Center is located on the east central coast of Florida and occupies most of Merritt Island and the Canaveral Peninsula (Figure 1). Merritt Island National Wildlife Refuge shares a common boundary with KSC. Contiguous with and to the north of the refuge and KSC is the Canaveral National Seashore operated by the National Park Service. Natural ecosystems of these areas are important habitat for resident and migratory species of wildlife and for a rich flora of temperate and subtropical species. A number of these plants and animals are included on federal and state lists of endangered or threatened species.

Concern by NASA for the long-term integrity of these ecosystems has prompted a series of studies to inventory resources prior to the onset of the shuttle launch schedule and to develop recommendations for continuous inventory (monitoring) programs. The purpose of this paper is to outline the progress made toward the inventory of terrestrial ecosystems and the evolution of an ecosystem monitoring program.

Initial Inventory

Initial biologic studies in the period 1972–75 were done via a series of grants between NASA/KSC and biologists from the University of Central Florida. An inventory was done of vascular plants (Poppleton et al. 1977) and bryophytes (Whittier and Miller 1976) of Merritt Island. Ehrhart (1976a) provided an annotated list of the herpetofauna. In addition, Ehrhart (1976b) reported data from a 3-year live-trapping study of small- and medium-sized mammals on three study sites. Extensive data on the avifauna were available from the Fish and Wildlife Service.

Contribution No. 19 of the Merritt Island Ecosystems Studies supported through Contract No. NAS10-8986, NASA/KSC.

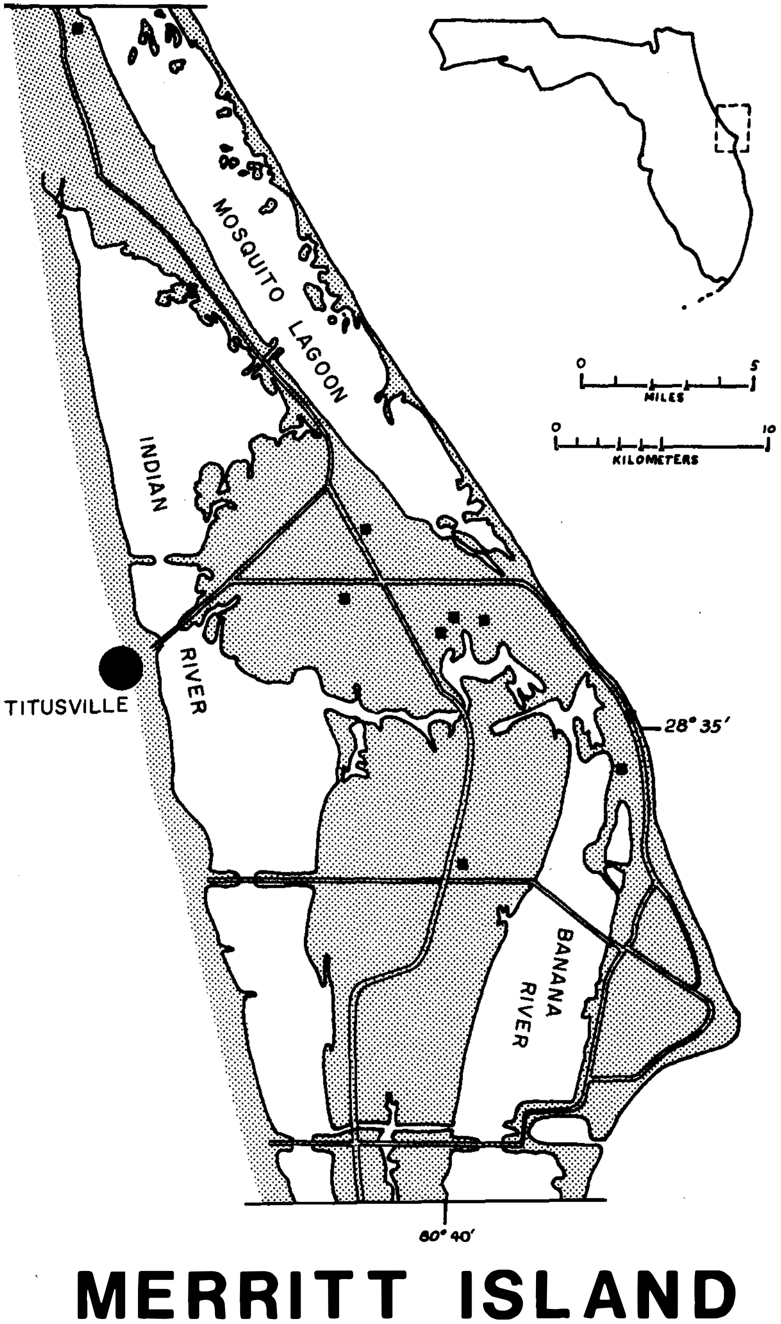

Figure 1. Merritt Island and the Canaveral Peninsula, Brevard County, Florida. The locations of the ten reference stands are indicated by the solid squares.

Thus, the initial inventory documented the flora and terrestrial vertebrate fauna of Merritt Island. Details on the nature of plant and animal assemblages in particular terrestrial habitats were, however, limited to only a few sites.

Base-line Inventory

A contract was established between NASA/KSC and the original study team from the University of Central Florida to complete the inventory of selected terrestrial ecosystems in the period 1976–79. The overall objectives of the base-line inventory were (1) to quantitatively describe the features of approximately 30 stands which were representative of the mature and relatively undisturbed plant community types found on or adjacent to Merritt Island; (2) to map the natural plant communities of Merritt Island; and (3) to document the temporal variation in the demography and diversity of small mammal populations in several typical plant communities.

Progress toward meeting these objectives will now be discussed and limitations in the inventory process will be noted.

Plant Community Analysis

A plant community analysis was necessary to develop a data base with which to compare future inventories and to establish criteria for mapping the communities. Wetlands were not sampled because the National Wetlands Inventory will provide the necessary data on these systems.

Study areas were located on or adjacent to Merritt Island. Areas on the adjacent mainland were included in the study to foster an understanding of successional and community similarities and differences among island and mainland sites. Potential study areas were located by field reconnaissance and by examination of county soil maps, USGS topographic maps and aerial photographs.

Thirty-four stands of relatively mature vegetation were found to be suitable for detailed inventory and analysis. Final study area selection was on the basis of the site being relatively homogeneous in terms of stand characteristics (size of trees, species composition), soil and topography. Areas were not acceptable for sampling if evidence was found of recent modifications of drainage, selective cutting, grazing or fires. Stands were not accepted if less than a hectare of undisturbed area existed.

Inventory of stands was by objective sampling. Tree, shrub and herbaceous layers, or those layers that were present, were analyzed to yield quantitative data on density, frequency and basal area for tree species, frequency and density for shrub species, and frequency and canopy coverage for herbaceous plants.

Forested areas were sampled by point-centered quarter method and importance values (relative frequency + relative density + relative dominance = importance value) were calculated for the tree species (Cottam and Curtis 1956). In hammocks, stems of shrubs, tree seedlings, and woody vines were counted in 20 by 79 in. (0.5 by 2.0 m) plots centered on the points used to study the tree layer. A 20 by 8 in. (0.5 by 0.2 m) plot was nested within the shrub plot to sample the herb layer. Canopy coverage was estimated for each herbaceous plant (Daubenmire 1959). In addition, plant species lists were made for each area independent of point and plot samples.

Sampling other habitats or dominance types differed in detail from methods employed in the hammocks. Lack of conformity in method diminished the opportunity to make direct ecological comparisons, but recognized that uniform sampling methods are not available for all types of terrestrial vegetation, even in a limited geographic region.

Analysis of the stand inventory data suggested the following composition by community type: hammocks (9); pine flatwoods (5); grassy swales (3); sand pine scrub (6); coastal scrub (6); coastal dunes (3); and coastal strand (2). For brevity, the discussion will focus on hammocks.

We believe any investigator would agree with the identification and classification of the hammocks as done in this study. However, our data suggest these communities to be remarkably heterogeneous in spite of similarity in appearance (life form). Pair-wise comparisons of the floristics of the hammocks with Jaccard community coefficients revealed the percent similarity did not exceed 38 in any comparison and was as small as 12 in one comparison (Table 1). An examination of the leading tree dominant as measured by importance value showed that six of the nine hammocks shared the leading dominant, *Sabal palmetto,* whereas, it ranked second in the remaining three stands. The subtle but continuous variation that characterizes these stands suggests that further ecological stratification is necessary.

The results of this local plant community analysis call attention to several issues relevant to terrestrial habitat inventory and analysis. Firstly, the presence of relatively mature stands is critical to the assessment of the habitat potential of the landscape and to sorting out the endpoints of successional seres as indicated by polyclimax theory. Secondly, published records of inventory data from mature and successional stands increase in value as man continues to modify the landscape and yet strives for better predictive models of habitat potential for resource management. Lastly, most plant sampling methods are efficient in only a limited number of community types; indeed, this problem has led to a plethora of techniques and a lack of standard methodology. This latter problem is serious enough to warrant an attempt to formulate a manual of standard methods for habitat description based on the consensus of resource biologists and plant ecologists.

Table 1. Jaccard community coefficients for nine hammocks. The coefficient is a measure of floristic similarity (percent) (Mueller-Dombois and Ellenberg 1974).

Hammock	Jaccard community coefficient								
(1)	100	—	—	—	—	—	—	—	—
(2)	31	100	—	—	—	—	—	—	—
(3)	15	21	100	—	—	—	—	—	
(4)	21	25	16	100	—	—	—	—	—
(5)	20	30	21	30	100	—	—	—	—
(6)	36	36	25	30	25	100	—	—	—
(7)	35	33	13	18	23	32	100	—	—
(8)	34	38	36	27	34	30	26	100	—
(9)	31	35	12	21	18	28	21	22	100
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Habitat Classification and Mapping

Preparation of a map of the vegetation of Merritt Island is in progress. The purpose of the map is to indicate the distribution of the major plant communities to aid management and planning activities of NASA/KSC, Fish and Wildlife Service, and National Park Service. Previous maps of the vegetation of Merritt Island were of low resolution and offered little insight into local conditions (Küchler 1964, Davis 1967).

Our working classification of community types is: hammocks (forests dominated by broadleafed evergreen species), sea oats (*Uniola*) zone, coastal strand, coastal scrub, sand pine scrub, pine flatwoods, grassy swales, palm savanna and undifferentiated wetlands. As noted before, wetlands are being classified by the Fish and Wildlife Service according to the system of Cowardin et al. (1977). These plant community types represent an integrated expression of the ecosystems at this particular time (Küchler 1973). There is continuous variation within each type owing to past land-use patterns, small scale changes in topoedaphic features, and the history of fires. These variations will not be reflected on the final map of the vegetation.

Alternative means of classifying communities are available, for example, physiognomic, species dominance, or floristic composition. The working schema proposed for Merritt Island is primarily based on growth-form or physiognomy. However, the names of the types tend to reflect terms used locally or the dominant species. A brief diagnostic characterization of the community types is being prepared to accompany the map to help avoid the inevitable ambiguities which will arise in practical usage.

The final map will be at a scale of 1:60,000. Community types will be designated in contrasting colors or patterns. Overlays of other physical or biological features may be developed as needed. Smaller scale resolution of the plant communities, which might result from more detailed ground-truth data, remains as an option when necessary for management decisions. For example, management of endangered plant species will require greater detail in local habitat evaluation.

A major shortcoming of this example of habitat inventory and, I suspect, many others is that the final product may best be described as a cover map. The dynamic nature of the landscape cannot be illustrated in two dimensions. However, where successional patterns are well documented, the habitat type approach (sense of Daubenmire) may be employed to indicate the potential of the environment to support a plant community regardless of current conditions (Daubenmire 1968, 1976).

Small Mammal Populations

The objective of this work is to document the species composition and seasonal dynamics of small mammal populations in four of the plant community types identified in the base-line habitat inventory. The rationale for inclusion of a vertebrate group in the habitat inventory is: habitat inventories focused on plant community analysis go only part way in assessing ecological status of landscapes. Change is inherent and expected in ecosystems and the impact of changes should be interpreted at various levels in the trophic structure of ecosystems. Small mammals were selected as indicators of change in habitat quality owing to their sensitivity to environmental conditions, e.g., rainfall and primary production (Whitford 1976, Tast and Kalela 1971) and vegetative cover (Goertz 1964). Furthermore, because of their local abundance, sedentary nature, and trapability, small mammals lend themselves to study in continuous inventory programs.

Small mammal live-trapping has been done monthly since July 1976 (Table 2). Results of this work suggest certain conclusions with respect to habitat evaluation and environmental monitoring on Merritt Island.

Monitoring small mammals to evaluate change in habitat quality should concentrate on variation in number and composition of the suite of species in a particular habitat and on the variation in population size of the dominant species. In the Merritt Island studies, we believe that a shift in species numbers, the number of species trapped in a month or season, when compared with past trends may provide an early sign of ecosystem level stress. However, another indicator of concern is the status of the dominant species (a habitat may support more than one). Dominance in this context implies a species that is not cyclic in its population fluctuations and is not typically rare or near the limit of its tolerance for the prevailing habitat conditions. We believe that evaluation of the population status of subordinate species is most often problematical owing to sample variation. Thus, a shift in species number may indicate random changes in habitat quality, whereas, a change in the status of a dominant species that is coupled with a shift in species diversity will be indicative of fundamental change in habitat quality.

Concurrent trapping in contrasting vegetation types provides valuable insight into spatial and temporal dynamics of small mammal populations not otherwise available if only a single habitat type is under study. In addition, data from different combinations of dominant small mammals facilitates analysis of change and causal relations. This consideration is especially important when man-induced stresses may be chronic and local in occurrence.

Agencies with limited resources cannot be expected to carry out long-term intensive trapping to augment base-line studies. One approach to circumvent the

Table 2. Seasonal variation in minimum numbers of the dominant rodent species in four habitat types on Merritt Island, Florida, 1976–78. The trapping areas are 3.5 acres (1.4 ha) with the exception of the hammock which is 2.7 acres (1.1 ha). Trapping procedures were standardized on all areas.

Habitat type (rodent)	Mean minimum numbers (coefficient of variation × 100) and sample size			
	Spring[a]	Summer	Fall	Winter
Pine flatwoods *(Peromyscus gossypinus)*	10(19)6	6(50)9	5(29)9	6(41)7
Hammock *(Peromyscus gossypinus)*	23(63)6	16(27)9	14(70)9	18(68)7
Coastal scrub *(Peromyscus polionotus)*	17(37)6	7(55)8	5(54)9	10(35)7
Coastal dunes *(Peromyscus polionotus)*	19(21)6	17(18)8	20(31)7	22(46)7

[a]Spring: March-May; Summer: June-August; Fall: September-November; Winter: December-February.

problem might be to sample one season per year. Seasonal patterns in minimum numbers of dominant small mammals on Merritt Island reveals considerable variation (Table 2). Moreover, it appears that the optimal season for trapping varies with both habitat type and species of dominant rodent.

A Continuous Terrestrial Ecosystem Inventory

The purpose of this section is to give definition to a Continuous Terrestrial Ecosystem Inventory for the Kennedy Space Center and Environs. The inventory is intended to collect, interpret, and report on data which permit an evaluation of the status over time of selected population groups in several terrestrial ecosystems. Duration of the program may span two decades.

The overall purpose of the inventory is to ensure that ecosystem degradation does not go undetected. This goal is consistent with management policy of NASA/KSC and the Fish and Wildlife Service.

Inventory

The continuous inventory as outlined here follows the stepwise procedure for ecosystem monitoring as envisioned by Johnson and Bratton (1978). Three steps are involved: (1) by inference from empirical evidence or inference from other similar systems, hypotheses are formulated about changes in the ecosystems under observation; (2) a regular inventory of ecosystem components is conducted; and (3) hypotheses are tested and appropriate reformations made. The whole process recycles on a schedule which is determined by the consequences of significant ecosystem change occurring without detection.

Reference Stands

The focus of the inventory will be 10 sites that were initially studied during the plant community analysis and now are designated as reference stands (Figure 1). Included among the stands are the following community types: hammocks (3); pine flatwoods (3); coastal scrub (3); and coastal dunes (1). Detailed data on these stands are available from the base-line inventory. These data allow the formation of hypotheses with respect to status and future change to be anticipated in the stands. For example, it can be hypothesized that the pine flatwood sites will, in the absence of fires, be increasingly dominated by hardwood growth and reproduction.

Regular inventory of the reference stands will be conducted to measure change in the plant community. Five permanent line transects, each 49 ft. (15 m) in length, have been established in each reference stand. Frequency of occurrence and canopy coverage of woody plant species will be recorded on each transect during the summer (July-August). The coastal dune site is an exception in that all plants are included in the measurements. Analysis of change in canopy coverage may be done with pooled or stratified subsets. In addition, species diversity measures may be calculated.

At KSC it may be necessary to inventory the line transects in the reference stands on an annual basis for the first five years of the shuttle program. Remeasurements at 2–5 year intervals may then be sufficient. Reanalysis of all the reference stands as done in the original base-line inventory might occur every 10 years. Thus, these measurements would be gathered twice more in this century.

The sites of the base-line population studies of small mammals are included among the reference stands. Thus, the range of variation in species diversity and population fluctuation is known. Retrapping of permanent grids on a seasonal or yearly basis will contribute to the analysis of ecological change among the reference stands.

Where We Go From Here

Most of us accept without question the classification and naming schemes of living organisms. Our means of accurate comunication would be severely impaired without these tools. In contrast to the relative ease with which we talk about species, the very important business of communicating about habitats and animal and plant communities is certainly in disorder if not near chaos. Published works indicate that authors define, inventory, and evaluate habitats with a combination of ordinary and novel methods. Synthesis of these data is seldom attempted, few generalizations have emerged, and even the dogma of the "edge" effect is being questioned.

Certainly a serious need exists for a habitat classification system applicable to the landscapes of the United States. An excellent start toward such a system is represented in the operational draft of the "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin et al. 1977). Refinement of this product during the current national inventory of wetlands will surely result in a highly workable system. An expansion of this system to include upland habitats is highly desirable. The ecoregion maps of the United States are a good start toward upland habitat classification (Bailey 1978). Further resolution is needed beyond the province and section level.

An upland habitat classification system should have a sound ecological basis in that geology, soils, drainage, and climate are coupled with the biota in a hierarchial schema. Preparation and publication of a working document should be encouraged at the earliest possible time. Some attention would need to be devoted to formulating a means of nationwide evaluation of the classification system.

The ultimate level of classification in the national wetlands system is dominance type. Terrestrial habitats are traditionally named after plant dominants. A great deal of attention will be needed to develop criteria for establishing dominance type. Details for standard methods may be beyond the scope of a single document aimed at national usage. Rather, separate manuals for the ecoregions may be most practical. Cooperative efforts between resource biologists and traditional terrestrial ecologists could result in the preparation and publication of these habitat guides.

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Coordinating Wildlife Habitat Inventories and Evaluations—Summary Statement

Merrill L. Petoskey

I want to thank all the people that appeared here this morning. From the examples given, it is quite obvious there are positive efforts being made to inventory wildlife habitat and the species of wildlife living therein.

Legislation passed during the past decade and the administrative regulations relating thereto have greatly increased the need for better renewable natural resources inventories. There is much work being done but it is obvious there is need for uniformity, coordination, and in-depth storage which provides for easy retrieval and use. My concluding remarks can best be drawn from the papers presented on state and federal efforts.

To summarize, inventory methods vary among the federal agencies and among the states, making comparisons of trends of similar wildlife species exceedingly difficult or impossible. There seems to be no regional or national standardized methods for data gathering, storage and retrieval, although the discussions today indicate that there are systems that can work. Deciding on a uniform system is an imperative need.

Funding, agency views and needs, the variety of state and federal programs, and the variety of assessment requirements of the numerous federal and state laws all contribute to the inventory/assessment problem.

To conclude his paper, "Buzz" Besadny offered four recommendations. They were:

1. A systems analysis approach to problem solving is essential and must be developed and used by all decision makers to identify the proper course of action.
2. Wildlife inventory/assessment work must use standardized methods and yield data retrievable from a computerized data storage bank.
3. The federal government should take the lead in encouraging ecosystem level fish and wildlife research to be conducted by universities and governmental agencies. (As an aside, I don't necessarily feel that the federal government should take the lead. It behooves all of us at state, private, and federal levels to make this determination.)
4. The International Association of Fish and Wildlife Agencies should take the lead in standardizing the inventory/assessment process and in coordinating efforts to develop a computerized data storage bank which can be used by all governmental agencies. These efforts could be most effectively implemented by the Association's regional organizations with a series of workshops.

It is important to note that Dr. Allan Hirsch's comments were very similar to those offered by Besadny. It is also important to note that the federal agencies have concluded a five-agency agreement in an attempt to strengthen cooperation. However, we believe this agreement should include the states. This could be accomplished through the auspices of the International Association of Fish and Wildlife Agencies. I would concede, however, that it is much simpler for five federal agencies to develop uniformity and agreement than it is for 50 states. We believe the International Association, when it formed a committee to participate in this session, made a major first step towards developing uniformity among states and with the federal government.

We would recommend, as Besadny did, that this committee continue its work, in concert with the federal agencies, to develop a national symposium on wildlife habitat inventory classification and assessment. This could be done with regional meetings representing the four regions of the Association.

There is an additional point which I would like to make. You may have noted earlier in my remarks the use of the word "private." The matter of private expertise was brought to my attention by a friend of mine, Norm Roller, whom I believe is with us today. Norm is a member of the Environmental Research Institute of Michigan. He is concerned that the state and federal agencies may not be aware of the assessment activities that are being done in the private sector. It is his feeling, and I agree with him, that a panel made up entirely of governmental habitat evaluation specialists may not result in comprehensive consideration of all approaches and techniques currently in use. He may be wrong, but he also may be right. In my dealings with him, I have found him most often the latter. To be sure, my final recommendation would be to include the private sector in any deliberations on coordinating wildlife habitat inventories and evaluations.

Frankly, at this stage in the game, the situation we find ourselves in reminds me of arriving early at the concert hall. The orchestra is in the process of tuning up, with the individual instruments being heard with much discord. We wait for the maestro to step on the podium, raise his baton, and bring harmony to our efforts. We are ready now and shouldn't wait much longer for the music to begin.

Managing International Living Resources

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Conservation of Living Resources in Antarctica

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Introduction

Antarctica and the Southern Ocean (Figure 1) are the only major land and water masses on earth that remain relatively unaffected by man's activities. There has been no mineral development on either the continent or the continental shelf and, of the living resources, only several species of seals, whales, and fish have been harvested commercially. However, the situation is changing. Economic incentives, depletion of mineral and fishery resources in more accessible areas, extension of coastal state fishery jurisdictions to 200 miles (320 km), and growing human demands for energy and protein are causing growing interest in the resources of Antarctica and the Southern Ocean.

Living Resources

Antarctica itself is an ice-covered biological desert. In contrast, the surrounding ocean and sub-Antarctic islands are highly productive and support a diverse biota which includes whales, seals, birds, fishes, squids, crustaceans, phytoplanktons, and seaweeds (see the reviews by SCAR/SCOR 1977, Everson 1977, and Bengtson 1978).

Seals and Whales

The presence and relative abundance of seals and whales in the Antarctic have been known since Cook's second voyage around the world (1772–1775). Sealers, attracted by Cook's reports of numerous fur seals (*Arctocephalus sp.*) and elephant seals (*Mirounga leonina*) on South Georgia Island, discovered, and within several decades, nearly exterminated fur seal and elephant seal populations on Kerguelen, Macquarie, Heard, and the South Orkney Islands as well as on South Georgia (Stonehouse 1972). The South Shetland Islands, the final refuge of

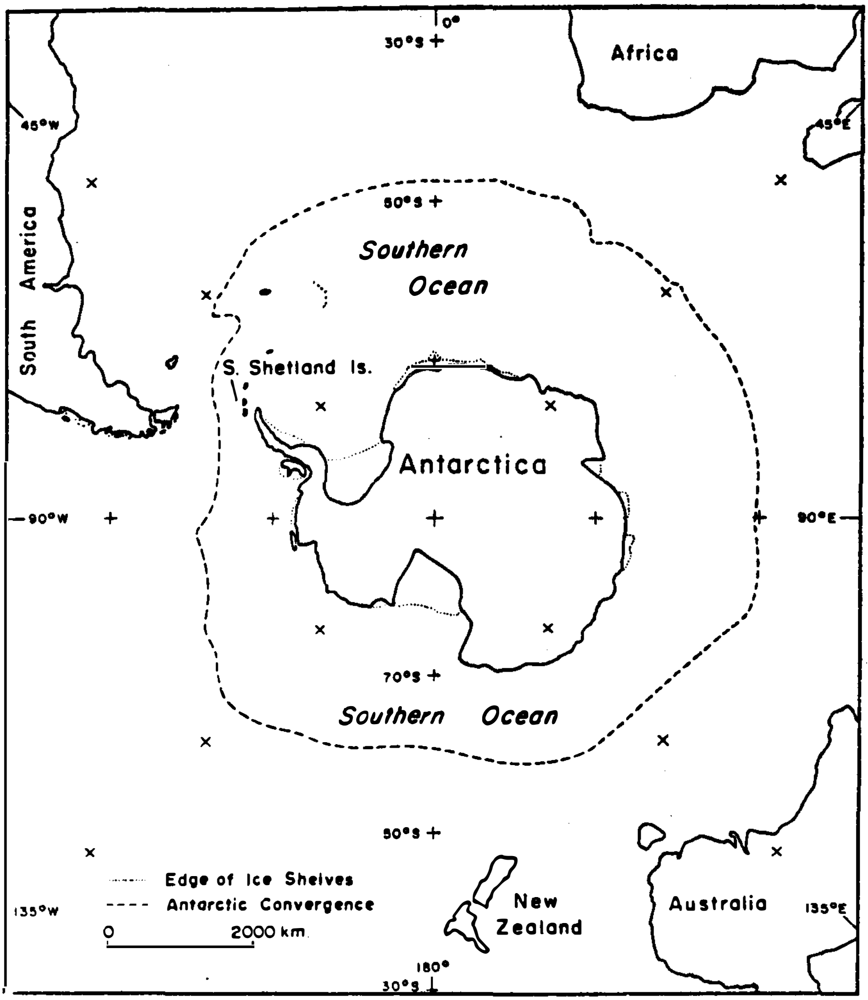

Figure 1. Antarctica and the Southern Ocean (from Elliot 1977).

the Antarctic fur seal, were discovered in 1819, and, in 1829, a British captain, W.H.B. Webster, wrote in his journal, "The harvest of the seas has been so effectually reaped that not a single fur seal was seen by us during our visit to the South Shetland Group." (noted in King 1969).

Modern whaling in the Antarctic began with the establishment of a land station at Grytviken on South Georgia Island in 1904. Until the mid-1920s, whaling was carried out from land stations or from factory ships moored in harbors and focused on humpback whales (*Megaptera novaeangliae*). Factory ships with stern slipways and on-board processing facilities were first utilized in 1925 and, by 1930, 41 factory ships and 200 catcher boats were engaged in Antarctic whaling (King 1969, Stonehouse 1972. Mackintosh and Brown 1974, and Deacon 1977). Like sealing, whaling was poorly regulated and led successively to depletion of Antarctic stocks of humpback, blue (*Balaenoptera musculus*), and fin (*Balaenoptera physalus*) whales (see Mackintosh and Brown 1974, Chapman 1974a, 1974b, and McHugh 1974).

Antarctic Krill

Investigations carried out during the early years of the whaling industry identified the importance of Antarctic krill (*Euphausia superba*) in the diets of humpback, blue, and fin whales, and in the Antarctic marine food web in general (Marr 1962, Deacon 1977, and Green 1977). Today, Antarctic krill is viewed as the living resource with the greatest potential commercial value in the Antarctic (Everson 1977). Krill occupies a central role in the Antarctic marine food web and over-harvesting could have much greater consequences than over-harvesting of seals and whales that occupy higher trophic levels.

The central role of krill in the Antarctic marine food web is illustrated in Figure 2. It is the dominant herbivore in the Antarctic marine food web and the principal component in the diets of fin, blue, humpback and minke whales, crabeater seals and Antarctic fur seals, Adelie, chinstrap, macaroni, and rockhopper penguins, several other species of seabirds, and several species of fishes and squids. Some of these species are eaten in turn by sperm whales, killer whales, leopard seals, etc. (see the reviews by SCAR/SCOR 1977, Everson 1977, Green 1977, Bengtson 1978, and Bakus et al. 1978).

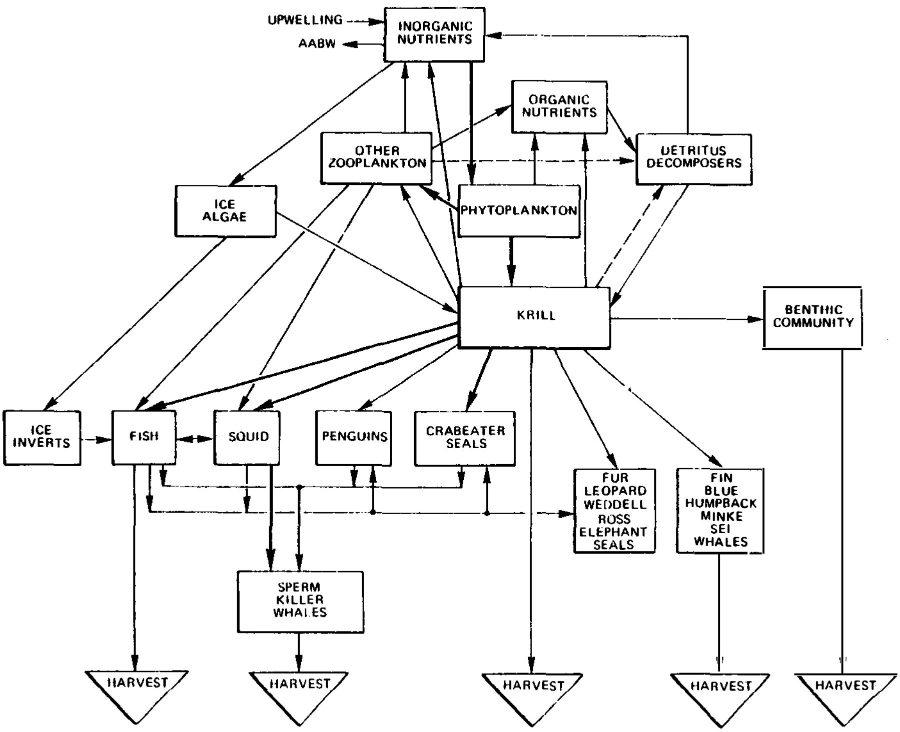

Figure 2. Conceptual model of the Southern Ocean (from Bakus et al. 1978).

Krill is known to form dense aggregations or swarms and to be most abundant in the Weddell Sea, the East Wind Drift, the Weddell Drift, and the area around South Georgia Island (Figure 3, Marr 1962, Nemoto 1968, and Mackintosh 1973). It is not known whether there is a single krill population or several discrete populations. Similarly, the cause(s) and function(s) of swarming behavior and the factors limiting distribution and abundance are unknown. Life span, growth rates, abundance, and productivity are subjects of speculation (see the reviews by Everson 1977 and McWhinnie and Denys 1978).

There have been no comprehensive surveys or direct measures of krill abundance or productivity. Estimates of krill abundance, productivity, and sustainable yield have been derived indirectly from estimates of phytoplankton production

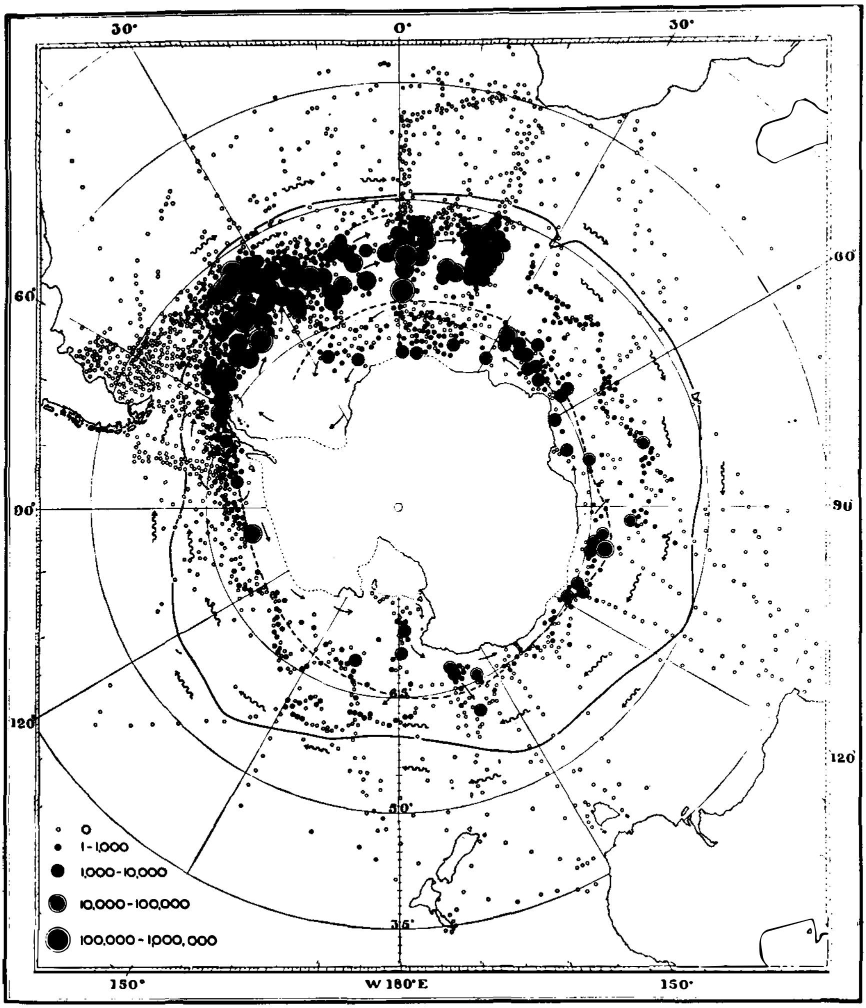

Figure 3. Distribution of krill in the Southern Ocean (from Marr 1962).

and from estimates of the abundance and krill consumption rates of whales, seals, birds, fishes and squids. Estimates of standing stock and production vary by more than two orders of magnitude, ranging from 44.5 to 7,500 million metric tons (mmt) and from 25 to 2,250 respectively (Marr 1962, Gulland 1970, Mackintosh 1970, Moiseev 1970, Lyubimova et al. 1973, and Green 1977).

The Krill Surplus Hypothesis

Several authors (e.g., Zenkovich 1970, Mackintosh 1970, Moiseev 1970, and Gulland 1970) have stated or inferred that the difference in krill consumption by present and pre-exploitation stocks of krill-eating whales may represent a krill "surplus" which can be harvested by man. Mackintosh (1970), for example, calculated that Antarctic stocks of krill-eating whales have been reduced by about 85 to 90 percent due to poorly regulated harvesting and that there now could be a krill surplus "anywhere between about 33 million and 330 million tons." More recently, Laws (1977a, 1977b) calculated that the biomass of Antarctic baleen whales has been reduced "from 43.09 million metric tons at the beginning of this century to 6.62 million tons now, implying a krill 'surplus' of some 153 million tons . . ."

More than 70 years have passed since the beginning of modern whaling in the Antarctic and there is an increasing awareness that populations of minke whales, crabeater seals, fur seals, and other krill predators likely have increased in response to the increased availability of krill and that there presently may be little or no surplus that can be taken without affecting the abundance or productivity of one or more krill predators (Laws 1977a, Green 1977, Bengtson 1978, and McWhinnie and Denys 1978). In fact, there is evidence which suggests that populations of minke whales, crabeater seals, Antarctic fur seals, and several species of penguins have increased in size as the numbers of krill-eating whales were reduced (see the summaries by Laws 1977a and Bengtson 1978).

Experimental Krill Harvesting

In 1976, the total worldwide catch of marine living resources was about 73.5 million metric tons (FAO 1977). It is not surprising, therefore, that speculation to the effect that Antarctic krill could support a fishery equal to or greater than all other fisheries combined, led to harvesting efforts.

Experimental harvesting was begun by the Soviet Union and Japan in the early 1960s. In the 1970s, Poland, West Germany, Norway, Taiwan, East Germany, and Spain also have been involved (Chenard et al. 1976 cited in Bakus et al. 1978). There have been technical difficulties in catching and processing krill but most of these appear to have been solved. Products being developed, tested, or marketed include whole krill, tail meats, minced meats, paste, powder, meal and by-products such as chitin, pigments, and fat (Grantham 1977).

Markets have been slow to develop and, at the present time, the annual catch by all nations involved in the developing fishery probably does not exceed 100,000 (0.1 million) metric tons (Everson 1977 and Bakus et al. 1978). If marketing problems are solved, markets and the fishery could escalate rapidly.

Possible Consequences of Krill Harvesting

While there can be little doubt that the population(s) of Antarctic krill are sufficient to sustain a major fishery, available information on the biology and ecology of the species is insufficient to predict the potential size of that fishery or its possible impacts on species which are dependent upon or compete with it. Since krill occupies a central role in the Antarctic marine food web, exploitation could result in decreases in dependent species and/or increases in competing species, as well as decreases in the absolute or relative abundance of krill. Harvesting at relatively low levels could prevent or retard the recovery of whale populations that have been severely depleted by poorly regulated harvesting.

Available information suggests that krill fishing will be concentrated in open-ocean (ice free) areas which are, or were, the major feeding grounds of krill-eating baleen whales, that fishing will occur primarily in the summer months when whales are present on the feeding grounds, and that fishing effort will be selectively focused on the same kinds of high-density krill swarms which are fed upon by baleen whales and, perhaps, other predators. Thus, levels of krill harvest that may have an immeasurable effect on overall krill density may result in significant reductions in the numbers or sizes of krill swarms and have a significant adverse impact on predators, such as baleen whales, that are adapted to feeding on swarms. Since competitive ability may be affected by relative abundance, it further is possible that depleted populations of blue, fin, and humpback whales may be affected to a greater extent than more abundant populations of minke and sei whales.

It is not known if, how, or to what extent, Antarctic krill competes with other species in the Antarctic marine ecosystem. If the distribution or abundance of other species are being limited because they are being out-competed by krill, a krill fishery could reduce *E. superba*'s competitive superiority and one or more of the competing species conceivably could be "released" and replace *E. superba* as the dominant herbivore in the Antarctic marine food web. The replacement species might be less accessible (e.g., a nonaggregator) or acceptable to fishermen, whales, or other predators and the value, as well as the basic structure, of the ecosystem would be altered, perhaps permanently.

International Conservation Efforts

Both the Scientific Committee on Antarctic Research (SCAR) and the thirteen Antarctic Treaty nations have recognized the uncertainties and risks associated with exploitation of Antarctic marine living resources, particularly krill. SCAR, a nongovernmental committee created in 1958 by the International Council of Scientific Unions (ICSU), has constituted a working group on living resources of the Southern Ocean (Working Group 54). This working group has developed and is seeking support for a comprehensive research proposal entitled "Biological Investigations of Marine Antarctic Systems and Stocks" (BIOMASS—SCAR/SCOR 1977). On the political side, the Antarctic Treaty nations are attempting to develop and conclude a convention for the conservation of Antarctic marine living resources (U.S. Department of State 1978).

BIOMASS

BIOMASS, in essence, is a compendium of research proposals covering a range of subjects from ecosystem modeling and oceanography to seaweeds and remote sensing. The principal program objective is "to gain a deeper understanding of the structure and dynamic functioning of the Antarctic marine ecosystem as a basis for future management of potential living resources."

Three types of activity are envisioned: sea-going experiments and surveys; shore-based experiments and year-round observations; and data analysis, synthesis and modeling. The main implementation phase consists of two major international, multi-ship, multidiscipline efforts; the First International Biomass Experiment (FIBEX) scheduled for austral summer 1980–81 and the Second International Biomass Experiment (SIBEX) scheduled for austral summer 1983–84. The final phases, consisting of data analysis, data synthesis, and provision of scientific advice concerning resource utilization, are scheduled for completion in 1986.

Living Resource Convention

With regard to the living resources convention, the delegates to the Ninth Antarctic Treaty Consultative Meeting, held in London from 19 September to 7 October 1977, recognized the need for a conservation regime, as well as a comprehensive biological research program. They therefore recommended that their governments intensify scientific research related to Antarctic marine living resources and that "To the greatest extent feasible, they cooperate broadly and comprehensively in scientific investigations, and in the exchange of information therefrom . . ."

They also recommended that a definitive regime for the conservation of Antarctic marine living resources be concluded before the end of 1978; that a special consultative meeting be convened to draft a convention which could be the subject of a formal diplomatic conference; that the regime should explicitly recognize the prime responsibilities of the consultative parties; that the provisions of Article IV of the Antarctic Treaty should not be affected by the regime; that the regime should provide for effective conservation of marine living resources in the Antarctic ecosystem as a whole; that the regime should cover the area of specific competence of the Antarctic Treaty (south of 60° South latitude); that the area should extend north of 60° South latitude where necessary for effective conservation; and that the regime should not apply to species already regulated pursuant to existing international agreements (i.e., seals covered by the Convention for the Conservation of Antarctic Seals and whales covered by the International Whaling Convention).

In response to these recommendations, a special consultative meeting was held in Canberra, Australia from 27 February to 16 March 1978 to draft a convention text which could be used as a negotiating document at a formal diplomatic conference. Although a draft text was produced, it was not acceptable to all parties and the meeting was adjourned and reconvened in Buenos Aires, Argentina from 17 to 28 July 1978 (Barnes 1978a). The Buenos Aires meeting also failed to produce a text acceptable to all parties and an informal consultation subsequently was held in Washington, D.C. from 18 to 26 September 1978 (Barnes 1978b). The Washington consultation also failed to resolve all remaining disagreements and a convention was not concluded before the end of 1978 as had been recommended by the delegates to the Ninth Antarctic Treaty consultative meeting.

Agreement has been reached on all but a few issues related to the conservation convention and a second informal consultation recently was held in Bern, Switzerland (12 to 16 March 1979) to try to resolve the remaining issues. This informal consultation was partially successful and there apparently is but one issue that must be resolved before a decisive meeting can be scheduled and the text of the draft convention made public. Further consultations are occurring through normal diplomatic channels and it is hoped that a diplomatic conference to conclude the convention can be convened in May or June of this year.[1]

The Need for Interim Measures and a Conservation Plan

If a conservation convention is concluded and signed this year, two or more years almost certainly will pass before it is ratified by a sufficient number of countries to come into force. If the krill fishery develops rapidly or if it is concentrated in one or two small areas as presently is the case, over-harvesting could occur in the period between signature and ratification—i.e., in the "interim" period. Therefore, a mechanism is needed to control harvesting and fishery development until the convention is ratified and effective conservation measures can be implemented.

Interim measures should include an upper limit as to the quantity of krill that can be taken from areas such as the Scotia Sea, the Bellingshausen-Amundsen Seas, the Ross Sea, and the Weddell Sea. The limits should be based upon an assessment of the best available biological data and should take into account the risks and uncertainties associated with our scant knowledge of the biology and ecology of krill and krill predators. The interim measures also should provide for planning and conduct of scientific research and for exchange and analysis of scientific information including, but not limited to, catch/effort statistics.

With respect to research and conservation measures, it is important to remember that the Antarctic Treaty nations are not required, and have not committed themselves, to support BIOMASS and that the conservation convention, when and if it comes into force, will provide only a mechanism for conserving Antarctic marine living resources and the ecosystem(s) of which they are a part. If research and monitoring programs are not required and carried out, and if conservation decisions are approached from the traditional perspective that adverse effects on target or dependent species must be demonstrated or reasonably certain before remedial or protective measures are taken, over-harvesting almost certainly will occur. If, on the other hand, necessary research and monitoring programs are conducted, and conservation decisions are approached from the perspective that harvest levels must reflect uncertainties associated with our knowledge of the resources and the ecosystem(s) of which they are a part, over-harvesting will be unlikely. The task, therefore, is to develop a research-regulatory scheme that will insure that fishery development does not progress faster than our knowledge of the nature, extent, and inter-relationships of potential resources.

[1]At the time of publication, the diplomatic conference had not yet been scheduled.

Perhaps the best way to develop Antarctic fisheries, while minimizing the risk of over-harvesting and adverse effects on dependent species, would be to approach development as a controlled experiment designed to assess resource potential and the impacts of harvesting and associated activities on target species, dependent species, competing species, and the ecosystem(s) of which they are a part. With respect to Antarctic krill, for example, it would be reasonably simple to postulate a series of hypotheses concerning population discreteness (identity), optimum yield, effects of harvesting, etc. and then to develop a series of experiments to test the various hypotheses.

Such an approach obviously would require careful planning, a major research investment, and, most importantly, international cooperation. The SCAR Working Group on Living Resources of the Southern Ocean has, or has access to, the required expertise and it seems logical that the Treaty nations should ask this group to develop a conservation plan designed specifically to achieve the intents and provisions of the conservation convention which is negotiated. To insure that the plan is promptly and effectively implemented, the Treaty nations should commit themselves to providing the necessary financial and logistic support. To insure that the plan is ready for implementation when the convention comes into force, the Treaty nations should formally designate plan development as a high priority in the interim period.

Summary and Conclusions

In summary, available information on the nature, extent, and inter-relationships of living resources in the Southern Ocean is insufficient to predict how harvesting and associated activities may affect target species, dependent species, or the ecosystem(s) of which they are a part. Although the risks and uncertainties associated with harvesting Antarctic marine living resources, particularly krill, have been recognized by the Scientific Committee on Antarctic Research and the Antarctic Treaty nations, actions taken to date may be inadequate to minimize the risks while at the same time permitting rational development. It would be desirable, therefore, to develop and implement a conservation plan which provides for fishery development as an integral part of a controlled scientific experiment.

The SCAR Working Group on Living Resources of the Southern Ocean could develop such a conservation plan and should be asked to do so by the Antarctic Treaty nations. The Treaty nations should commit themselves to abide by the plan and to provide the financial and logistic support needed to implement it.

Addendum

The purpose of this addendum is to illustrate, in general terms, how an Antarctic krill fishery might be developed as part of a controlled experiment designed to assess the potential magnitude of the resource and the possible impacts of harvesting and associated activities on the resource and species which are directly or indirectly dependent upon it.

The first step would be to divide the Southern Ocean into a number of control and experimental areas. Since available information on the demography of Antarctic krill is insufficient to designate areas on a strictly biological basis, it would be necessary to choose areas based, in part, upon other criteria. One possibility would be to use the Six Statistical Areas presently used by the International Whaling Commission (IWC) for managing commercial exploitation of whales in the Southern Ocean.

If the Six IWC Statistical Areas were chosen, certain of these areas (e.g, II, IV, and VI) could be designated as experimental areas and the remaining areas (I, III, and V) designated as control areas. Fishing in control areas could be designed primarily to identify and monitor the distribution and abundance of krill, whereas fishing in experimental areas could be designed primarily to determine how target and associated species respond to various levels and methods of krill harvesting.

To insure that fishing is carried out in accordance with the overall conservation objectives and plan, a permit system could be instituted to require that plans for experimental or commercial harvesting be submitted to, and approved by, the Antarctic Commission and Scientific Committee which will be constituted under the terms of the Convention. To insure that necessary research and monitoring is conducted, a fee on certain kinds of research could be required as a condition for obtaining a permit to fish.

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Joint Marine Mammal Programs between the U.S. and U.S.S.R.

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Introduction

The history of cooperation between the United States and the USSR in marine mammal conservation and research has been closely linked to the species, and their attendant management problems, of the North Pacific region, particularly in the Bering and Chukchi Seas. Although current cooperation spans a broad spectrum of species and geographic areas, such as in the Antarctic Seal Convention, the International Whaling Commission, and the Marine Mammal Project within the US–USSR Environmental Agreement, which is the principal subject of this discussion, there is still a concentration of joint effort in the general area of the North Pacific. This stems in large part from the present and historic utilization of marine mammal resources by the Native peoples of our west coast and Alaska, and Siberia. Several cultures, including Aleut, Koryak, Kamtchadal, Eskimo and Chukchi, depended mainly on marine mammals and they developed sophisticated technologies for their harvest and utilization. Expressions of art recovered from the earliest Eskimo middens include intricately carved pieces of marine mammal bones and ivory designed as functional tools (harpoon heads) and religious objects (amulets and figurines). To the present day these cultures remain, to a degree, dependent upon a variety of marine mammals.

Early exploration and settlement of the North Pacific region by Europeans was largely based on the search for wealth from furs, oils and ivory that could be derived from the abundant stocks of valuable marine mammals. Although the Danish explorer Vitus Bering, in the service of Russia, died during his second expedition to North America, members of his crew, including the great naturalist George Wilhelm Steller, survived by eating individuals of a remnant population of sea cows. Steller provided the only firsthand scientific observation of this species, which was subsequently named after him. They returned to Kamtchatka with accounts of an abundance of valuable sea otters and other marine mammals.

A flood of Russian adventurers and entrepreneurs followed. This resulted in extinction of the Steller sea cow, extirpation of sea otters from most areas of their range, drastic reductions in fur seals and walruses and some reductions in other marine mammal species. The Aleuts, as a people, were virtually decimated by being uprooted and displaced for labor in the process of building Russian America.

By the 1830s, however, the Russians began leaving the west coast of North America as the quantities of furs diminished and they could not maintain the expense of those colonies. Additionally, competition from a growing American and British presence was increasing.

American adventurers continued the exploitation of marine mammals where the Russians left off. Yankee whalers took their first bowhead whales in the Bering

Sea in 1848. Within 50 years these whales were severely depleted. Walrus hunting followed a similar pattern and those animals were driven to their lowest levels by the mid 1930s.

By the late 1800s pelagic fur seal hunting such as described in Jack London's *The Sea Wolf,* in combination with clandestine raids on the breeding grounds, precipitated another decline in the fur seal herds which had partly recovered during the latter years of Russian control. The drastic depletion of the northern fur seal eventually led to the first international agreement on marine mammals, the International North Pacific Fur Seal Convention of 1911. That convention established a management program, mainly by Russia and the United States, for enhancement and conservation of those seals. The fur seal convention also accorded total protection to sea otters; animals which occur almost entirely within the waters of the United States and Soviet Union. Another international agreement, the Whaling Convention of 1936, accorded protection to gray and bowhead whales, species of particular importance to the Soviet Union and the United States.

Aside from these agreements, there was little exchange of scientific information or interaction between the U.S. and U.S.S.R. pertinent to marine mammal conservation and management. That situation prevailed in spite of the great dependence on, and concern for, marine mammals, especially by the peoples that bordered the Bering and Chukchi Seas. In the late 1950s, however, a number of laboratories were established in the Soviet far east within the Pacific Research Institute of Fisheries and Oceanography (TINRO), significantly expanding the scope of Soviet marine mammal research.

On the U.S. side, limited research was conducted by the federal government (primarily fur seal, but also walrus, sea otter and polar bear work) and by some state and academic institutions on these and other species. There was no cohesive marine mammal program. In 1959, however, Alaska became a State and assumed research and management responsibilities for most marine mammal species occurring in its coastal waters. The importance of marine mammals to residents of Alaska was (and still is) such that a broad based marine mammal program was developed, augmenting efforts by the federal government and universities. Still, American and Soviet investigators were working for the most part independently and, except for limited contacts established by individual researchers and availability of scientific papers in Russian and English, there was almost no exchange of ideas, current information, or on-going research plans.

Scientists from both nations expressed the need and desirability of increased interaction. Thus, in the late 1960s the Fur Seal Commission meetings were expanded to include discussions of ice seals and walrus in the Bering Sea. These discussions heightened awareness of the scope of activities of American and Soviet scientists and helped to further establish contact among specialists. Nonetheless, the exchange of information between scientists from these two nations continued at an undesirable low level. This situation prevailed until 1972.

The U.S.–U.S.S.R. Marine Mammal Project

On May 23, 1972, the United States and Soviet Union signed an agreement on cooperation in the field of environmental protection. This agreement recognized the importance that the two countries placed upon solving the problems of environmental protection and that more progress could be made through cooperative research and conservation activities than by individual national action. Among the areas agreed upon was that of mutual cooperation in the "protection of nature and the organization of preserves" (Table 1). This aspect of the agreement evolved into Section V of the Environmental Agreement and included the Marine Mammal Project. The objective of this cooperative program is "to develop collaborative research into the biology, ecology and population dynamics of marine mammals of interest to both countries and thus contribute to sound management and conservation of these animals." Thus, the need for information to enhance the goal of better management of these species was recognized and enunciated at a very early stage in program development.

From this initial step a program of vigorous cooperation and joint research on marine mammals has evolved between our countries. The first meeting between Soviet and American marine mammal scientists under this program occurred in January 1973 during the meeting to organize and develop Section V programs. During those initial discussions. guidelines were established that have continued to influence the progress of this program. It was recognized that all species of marine mammals of mutual concern, in any geographic area of the world, could and should be subjects for cooperative study. At the same time, however, the area of concentration of cooperative effort was recognized as the North Pacific region, particularly the Bering and Chukchi Seas because both countries border those seas. A few species, such as northern fur seal and polar bear, were excluded from consideration within the project in an effort to avoid duplication of research with other ongoing international programs.

Table 1. Organization of U.S.–U.S.S.R. Environmental Protection Agreement.

Environmental Agreement US and Soviet Chairmen and Executive Secretaries	
I Prevention of air pollution	
II Prevention of water pollution	*Projects*
III Prevention of pollution associated with agricultural production	1. Conservaton of wild species of flora and fauna
IV Enhancement of the urban environment	2. Protection of northern ecosystems
V Protection of nature and the organization of preserves	3. Reclamation and revegetation of disturbed land
VI Protection of the marine environment from pollution	4. Biosphere reserves 5. Arid ecosystems
VII Biological and genetic effects of environmental pollution	**6. Marine mammals** 7. Plant and animal ecology
VIII Influence of environmental changes on climate	
IX Earthquake prediction	
X Arctic and subarctic ecological systems	
XI Legal and administrative measures for protecting environmental quality	

Generally speaking, the program consists of several levels of activity, including: (1) exchange of published information (i.e., significant new papers and books are exchanged at project meetings or at the annual Fur Seal Commission meeting in years between project meetings.)—a full set of exchanged materials is deposited in the library of the National Marine Fisheries Service (NMFS), National Marine Mammal Laboratory in Seattle, Washington, and duplicates are distributed to institutions involved in the subject research; (2) continuous exchange of current data (unpublished data resulting from cooperative research efforts is available to both sides, and is routinely exchanged—usually on a scientist to scientist basis); (3) research conducted under national programs, each side doing a portion of the work but coordinating to standardize methods, format and scope, and exchanging or jointly working up resultant data; (4) joint research programs involving exchange of scientific personnel and coordination of research elements as in (3) above. Operationally, the program involves development of proposals for collaborative work by each side that are discussed at the project meetings every 18 months, alternating between the U.S. and Soviet Union. On the U.S. side, a seven man steering/planning committee reviews proposals made by scientists throughout the marine mammal research community and assists in developing a coherent package to advance at project meetings. The Steering Committee also makes recommendations on policy and direction of the program. After agreement is reached at the project level, those proposals are advanced to the Joint Committee of the overall Environmental Agreement and, if approved by that body, then become binding commitments on the two sides.

Categories three and four are the substantive parts of the program and, in actuality, much of the cooperative work consists of a combination of unilateral research conducted under national programs and joint work involving exchange of scientists in both directions and joint analysis of data.

Pinniped Research

The earliest efforts within the program began in 1973 and involved pinniped studies in the Bering and Chukchi Seas. These studies were initiated because of recognition that national research efforts, while contributing greatly to the information base on biology of walrus and ice seals, only addressed part of the problem and that effective management of these species required a broader understanding of their population structure and dynamics. Both sides recognized that the populations of walrus, ringed, ribbon, largha and bearded seals occur over wide areas of the Bering and Chukchi seas, generally corresponding to the movement of the ice pack and transcending political boundaries. The same populations are harvested by both countries, at least for subsistence purposes by Native peoples. Therefore, management of these species, to be effective, must consider the total data base, including the harvest and other impacting factors from both sides.

The most successful of the initial efforts was the pinniped research cruise on the U.S. vessel, *Alpha Helix* during the summer of 1973. Two Soviet scientists participated in this cruise during which studies of morphology, physiology, taxonomy, and distribution were conducted on walrus and several species of ice seals throughout the eastern Bering and Chukchi Seas.

In 1974, two U.S. scientists visited several marine mammal laboratories in the Soviet Union and studied extensive collections of osteological specimens and worked with Soviet colleagues on biology and taxonomy of walrus and seals. Among the data accruing from these and other continuing studies was information that contributed to a partial resolution of the taxonomy of the harbor seal (*Phoca vitulina*) group in the North Pacific.

During the fall of 1975 the first coordinated U.S.–Soviet aerial assessment of walrus was conducted in the Bering and Chukchi Seas. Results of these surveys were later evaluated and joint conclusions reached on population estimates and distribution of walrus in the surveyed areas. Over 96,000 walruses were counted on coastal hauling grounds along the Soviet coastline, and 30,000 to 40,000 were estimated to occur along the ice edge west of the International Dateline. Another 75,000 were estimated to occur east of the dateline for a total estimate of 201,000 to 211,000 animals. These estimates must be considered very crude, however, because of the difficulty of estimating numbers of walrus on pack ice.

In January 1976, a special conference on walrus and ice seal biology was held in Moscow. The conference reviewed much of the current state of knowledge of these species and developed preliminary plans for a long-range research plan which called for increased emphasis on studies at the community and ecosystem levels, the evaluation of current aerial survey techniques, and development of joint studies in Alaska and the Chukotka region of Siberia on herd structure and activity patterns. The special conference also developed a system of standard measurements for pinnipeds to be used in future research efforts and agreed to take up the question of standardization of cetacean measurements at future project meetings. The standard measurements have not been used in all subsequent work, but it is hoped that with increasing collaborative efforts, the sytem may eventually be fully implemented; perhaps even on a broader international scale.

Another major outcome of the conference was a discussion of the need for a conservation convention on walrus and ice seals in the Bering and Chukchi Seas and adjacent areas. It was pointed out that the national protective measures by both sides during the past decade had successfully reversed the declining population trends of two species, walrus and ribbon seal. Nevertheless, it was stressed that the populations of all five species considered (walrus and ribbon, largha, ringed and bearded seals), while increasing or already high and stable, were still in need of international management, particularly in view of potential environmental degredation by oil and gas and other development. Such a convention or a system of joint management of these species represents the ultimate goal of this cooperative research. During the last two years the scientists involved in the program have identified a list of basic management and conservation principles that should form the basis for an agreement and have carried the proposal forward to the stage of exploratory discussions between governments.

Joint studies on walrus and ice seals have continued steadily to the present. In spring, 1976, three U.S. scientists participated in the cruise on a soviet sealer/trawler, *Zagoriany*, in the Bering Sea and recorded important information on distribution and population structure and characteristics (such as age, sex, physical and reproductive condition) of walrus and three species of ice seals. Two Soviet scientists worked on seals in the northern villages of Alaska later that year and, including visits to several major museums, developed much new data on systematics and biology of several species, particularly ringed seal. Most recently, two cruises, one American and one Soviet, were conducted in the Bering and

Chukchi Seas in 1978 with joint scientific participation. Both cruises studied the distribution and biology of walrus and ice seals in their respective areas of deployment, gradually but certainly enlarging the data base on these species of great importance to the subsistence of both our Native peoples.

Cetacean Research

Cetacean studies within the program were initiated somewhat later than pinniped work, with U.S. participation in an expedition aboard the Soviet research whale catcher *Vnushitelny* from February to April 1975, in the eastern and central tropical Pacific. Work conducted included "Discovery" marking and extensive observation of large and small cetacean distribution and behavior in an area of the Pacific hitherto relatively little studied with regard to whales. During the cruise, approximately 2,000 large whales were sighted and 179 sperm whales were marked. Of particular note was the sighting of several groups of blue whales between Mexico and the Galapagos Islands and a large group of over 100 blues near the California coast. In addition, it was established that sei and Bryde's whales occur together in the same habitat.

The data obtained on distribution and behavior of large whales, during the *Vnushitelny* cruise and the *Zharkii* cruise in 1977, particularly that which will result from the "Discovery" marking on both cruises, is of major significance to the work of the International Whaling Commission.

Over 6,000 delphinids were sighted during the cruise. They included 10 species of the genera *Stenella, Steno, Tursiops, Peponocephala, Grampus, Orcinus Lagenodelphis* and *Globicephala*. The information gained on distribution, herd size and densities was of direct value to the National Marine Fisheries Service porpoise/tuna program which is monitoring the status and trends of populations of porpoises involved in the eastern tropical Pacific yellowfin tuna fishery.

Exchanges of scientists during 1975, 1976, and 1977 enabled collaboration on a series of morphological studies on large and small cetaceans. One study compared the arrangement of blood vessels and muscle weights in the flukes and dorsal fins of several species of delphinids to better define the morphological basis of the hydrodynamics of these animals. A comparison of the ontogeny of two species of delphinids was carried out, and a major, continuing study examined the color patterns of several species of large and small cetaceans, primarily sperm and killer whales, with a view toward developing techniques to distinguish between wild populations and individuals within populations and herds. During this series of exchanges the major task of cataloging the cetacean specimens in Soviet and American museums was begun. The catalog has advanced substantially in the past year and should soon be completed.

In the past two years the scope of cetacean work within the program has broadened dramatically. Recent collaboration has involved Soviet participation in U.S. radio-tagging experiments on humpback whales in southeastern Alaska. Two Soviet scientists participated in field tests of remotely applied radio tags in the summer of 1977 through the area of Stevens Passage and Frederick Sound, 80–130 km south of Juneau, Alaska. That was the second year of a planned five year test program to determine the feasibility of radio tagging free-ranging large whales. The scientists implanted five radio tags during the study, four of which functioned correctly and enabled scientists to track the whales for several days over a number of miles.

Cooperative studies of the bowhead whale were initiated in 1978 with participation of a Soviet scientist in aerial surveys to develop more information on their occurrence, distribution and movements in the western Bering and Chukchi Seas. Such information is critical to determine whether all bowheads move along the north slope of Alaska and into the Beaufort Sea during the annual spring migration. If not, it could have an impact on our estimates of the population and ultimately on the U.S. bowhead whale management program. Exchanges of scientists are planned to study population characteristics and dynamics of Black Sea dolphins in comparision with those of the eastern tropical Pacific. If this tentative agreement materializes—and there is every indication that it will—one or two U.S. scientists will be able to conduct long-term studies based at a convenient laboratory in the study area. It will be an excellent opportunity to study the dynamics and structure of dolphin populations that have gone through a cycle of overexploitation, population collapse, strict regulation leading to partial recovery, and, currently, new stress from exploitation by neighboring countries. What can be learned from these studies may have significant implications for our management efforts on pelagic dolphins in the eastern Pacific.

In other program areas, joint work is planned on a wide variety of subjects, e.g., there are plans to expand information exchange on husbandry and care and maintenance of captive marine mammals—a project that originated during an exchange of scientists in 1977 and 1978 and who studied oceanaria and techniques in both the United States and U.S.S.R. Joint investigations by American and Soviet scientists will study the physiology and population dynamics of the Baikal seal in an effort to better understand the cause of an apparent decline in average physical condition of this species. This program will involve long-term work visits by a team of Americans in 1980, and perhaps beyond. Further, agreement has been reached to undertake joint studies on sea otter population and community relationships in Alaska and the Commander Islands. New work is also planned on northern sea lions and harbor seals in Alaska and the Soviet Far East to concentrate on life history, ecology and population status. Finally, we should mention again that the two governments are to begin exploratory discussions on the potential agreement for conservation of walrus and ice seals in the Bering and Chukchi Seas and adjacent waters. Although initially concentrating on those species, the agreement could include others and could ultimately evolve to a multilateral agreement as well.

At this point, we should say a few words about the mechanics of coordinating work within the program lest we leave the somewhat erroneous impression that exchanges of people and information always work smoothly. Unfortunately, that is far from the case and a number of problems have been addressed in the past three years, including the continuing problem of achieving timely communication of information on cruise dates and plans, people involved in exchanges, dates of travel, visa acquisition, etc. It seems ludicrous, but is nonetheless true, that in an age of almost instantaneous communication by satellite and even more sophisticated means, it is sometimes impossible to get a single yes or no in less than a week's time. Of course, the problem is primarily a function of the massive bureaucracies involved and the many clearances or approvals that must frequently be obtained. The only answer thus far has been to continue our efforts to circumvent choke-points and attempt to increase lead time when requesting critical information.

Of more substantive impact to the program, however, has been the continuing problem of lack of access to key areas of marine mammal concentrations, primarily along the coastal areas of the Soviet Far East, and a past attempt to limit the scope of project activities to the North Pacific region. The latter was solved by a compromise that recognized the North Pacific (including the Bering and Chukchi Seas) as an area of concentration while maintaining an unlimited scope of subject matter for project consideration. The problem of access is not so readily solved, but substantial progress was made at the last project meeting with tentative agreements for collaborative work in several locations that were previously closed. With continual pressure at both the project and Environmental Agreement levels, there is a positive feeling that access to key areas of marine mammal concentration will continue to open up.

In summary, substantial progress has been made in establishing a framework for cooperation and collaborative effort in the field of marine mammal research and management. The program has developed from a modest beginning involving a small number of scientists from each side, primarily concerned with walrus, ice seals, and large whales, to a much broader effort which now includes work on small cetacean and pinniped morphology, systematics, and population dynamics; the consideration of techniques and problems involved in capture and maintenance of marine mammals; and has provided recommendations for international agreements to conserve and manage the marine mammal resources of concern to both sides. The number of significant exchanges and joint efforts undertaken within the framework of the program have now become so numerous as to be difficult to summarize in a single discussion such as this. Similarly, the research conducted thus far has resulted in numerous reports and publications. Other papers are currently being organized into two joint compendia on pinnipeds and cetacea to be published in the Circular series of the NMFS during the next two years. In future years we anticipate the program to grow still further and to provide increasing opportunities for collaborative work between our two countries.

Management of Seals in the Northwest Atlantic Ocean

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> *. . . although we might wish to manage wild marine animals or their environment, as yet we don't know how. What perhaps we humans can manage are our own activities which affect the marine mammals, to our own ultimate benefit or harm.*
> *Holt 1978*

Introduction

Two species of phocid seals are hunted each spring in the Northwest Atlantic off eastern Canada. Harp seals *(Pagophilus groenlandicus)* which reproduce in the Gulf of St. Lawrence and on the "Front" off Labrador and Newfoundland represent an interbreeding stock (Lavigne et al. 1978) essentially isolated from other harp seals which breed off Jan Mayen and in the White Sea (Øritsland 1976, Sergeant 1976). Smaller numbers of hooded seals *(Cystophora cristata)* also breed off Newfoundland and to a lesser extent in the Gulf. Their relationships with hooded seals which whelp in the Davis Strait (Sergeant 1974) and off Jan Mayen are poorly understood.

Case histories of harp and hooded seals encompass almost every conceivable problem associated with the management of wild living resources. As is commonly the case for exploited wildlife and fisheries resources, quota regulation of harp seal hunting in the Northwest Atlantic was initiated following a marked decline in population numbers. Subsequently, exploitation of hooded seals was brought under increased management control. The objective of the present paper is to review and evaluate the development of management practices in relation to the history of the seal hunt in the Northwest Atlantic (Sergeant 1976) and to put the present management strategy for these seals into perspective relative to the management of other living marine resources.

History of Exploitation and Trends in Seal Abundance

Early evidence of human exploitation of harp and hooded seals has been found in Norse settlements of Southwest Greenland which date from about A.D. 985 until their demise ca 1500 (McGovern, personal communication). Sealing off Newfoundland became a documented annual event in the early eighteenth century. Initially seals were taken in nets set from shore (Coleman 1937, 1949), a practice which continues today in parts of Newfoundland and along the North shore of the St. Lawrence River (Beck 1965, Sergeant 1976). By the beginning of the nineteenth century, schooners were used to get men into the ice to hunt harp seals on whelping patches (Chafe 1923). Soon the seal hunt was second only to the cod *(Gadus morhua)* fishery in Newfoundland's resource-based economy (England 1969). Greatest annual catches occurred between 1820 and 1860 when over 500,000 seals were landed in some years (Chafe 1923). Catches of 680,000, 740,000, and 686,000 seals were reported in 1831, 1832, and 1844 respectively (Chafe 1923, Fisher 1955, Barchard 1978). These catches were comprised mainly of young harp seals, but also included older harps and a small percentage of hooded seals (Coleman 1937, Fisher 1955).

Despite the replacement of sailing ships with steam-powered vessels beginning in 1863, catches of seals in the Northwest Atlantic declined substantially towards the latter part of the nineteenth century, averaging about 341,000 between 1863 and 1894. Beginning in 1895 harp and hooded seal catches were recorded separately (Chafe 1923). Annual catches of harp seals continued to decline, averaging 249,000 between 1895 and 1911, and 159,000 between 1912 and 1940 (Fisher 1955). Annual catches plummeted as a result of the Second World War to an average of 46,000 harp seals between 1941 and 1948 (Fisher 1955), the lowest level recorded since the eighteenth century.

After the war, hunting activities escalated and annual catches of harp seals by Canada and Norway increased to an average of 316,000 between 1951 and 1960 (Capstick et al. 1976). It was only during this time that scientists began to collect biological data on the stock, and conducted the first attempts at stock assessment. As early as 1952 Fisher warned that "with continuing kill in the order of that in 1951 [456,000], the population would be unable to maintain itself and some restriction would be needed. . . ." Despite this, and later warnings (Fisher 1955, Sergeant 1959) no regulations were imposed on the harp seal hunt until 1961 when opening and closing dates were introduced for both the Gulf of St. Lawrence and the Front (Sergeant 1976). Adult females on whelping patches were protected in 1965, the same year that Norway stopped sealing in the Gulf and Canada imposed a limit of 50,000 harp seals on Canadian sealers operating in this area. During this same decade (1961–1970), annual catches of harp seals averaged 280,000 animals (Capstick et al. 1976).

It is now undisputed that the large catches of harp seals in the post-war years and the increased proportion of the catch comprised of animals aged one and older (Fisher 1955) resulted in a marked decline in population size and pup production as Fisher (1955) and Sergeant (1959) had predicted. Although the historical data are inadequate for accurately assessing population abundance prior to 1950 (Barchard 1978) it is evident that the reduction in stock size between 1950 and 1970 was in the order of 50 to 66 percent (Øritsland 1971, Lett and Benjaminsen 1977, Lett et al. 1977, 1978, Winters 1978). It was only after this decline was clearly evident (Ørtisland 1971, Sergeant 1971), and as a consequence of mounting public pressure to stop the hunt (e.g. Lust 1967, Davies 1970) that quota management was finally introduced in 1971 (Anon. 1972, Sergeant 1976, Lavigne et al. 1979) through the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF).

At the present time, management decisions are based on the view that the stock has responded to improved management practices and is presently increasing in numbers (Mercer 1977, 1978, Fisheries and Environment Canada 1978a). This conclusion emerged from several analyses of available biological data and hunt statistics, and from computer models of the population. These analyses have suggested that the population began to increase as early as 1972 (Lett and Benjaminsen 1977). However it is very difficult to give precise and accurate estimates of population size or of pup production because of deficiencies and uncertainties in the available data base (Walters 1976, Lavigne 1978). Since 1976, estimates of pup production from mathematical models and quantitative assessments have ranged from 250,000 to 378,000 (Lett and Benjaminsen 1977, Lett et al. 1977, 1978, Winters 1978, Sergeant 1978) although the quality of the data base is such that a much wider range of estimates is possible (Walters 1976). These levels of pup production suggest populations sizes of between 1.0 and 1.5 million harp seals in the Northwest Atlantic at the present time. Aerial censuses, incorporating ultraviolet photography to detect white-coated pups (Lavigne and Øritsland 1974). have not corroborated these estimates (Lavigne 1976a, Lavigne et al. 1977, 1979).

In comparison with harp seals, little is known about the biology of hooded seals in the Northwest Atlantic. Since 1895, short term fluctuations in catches and catch per unit effort have been greater than those observed for harp seals (Sergeant 1974). Long-term fluctuations in catches and catch per unit effort have also been noted. The reasons for these fluctuations are not well understood but may be related to climatic changes or other factors which affect the distribution of whelping hooded seals from year to year. The relatively small number of hooded seals in the Northwest Atlantic, compared with harp seals, and the location of hooded seal whelping patches on pack ice farther from shore may also increase the probability that large concentrations of seals go undetected by sealers and scientists in any given year.

The unknown relationship of hooded seals which breed on the Front off Newfoundland and those which breed to the north in the Davis Strait (Sergeant 1974, 1976) further confounds any discussion of Northwest Atlantic hooded seals at this time. Sergeant (1974) suggested that if hooded seals whelping off Newfoundland were an isolated stock, they would have been exterminated long ago. For years, adult hooded seals made up a large proportion of the catch, and the majority of these were breeding females (Sergeant 1974). One view is that hooded seals have persisted off Newfoundland only because of recruitment from unexploited hooded seals which whelp in the Davis Strait (Sergeant 1974).

Although analyses of biological data on hooded seals have been attempted in recent years, a very limited data base only extends back to 1971. At present there are insufficient data to permit adequate evaluation of current stock size, pup production or sustainable yield (FAO 1976, ICNAF 1978a). Despite this conclusion, it was suggested recently that pup production has fluctuated between 24,000 and 30,000 and that the stock has been exploited at approximately sustainable yield levels since the early 1960s (ICNAF 1978a).

Current Management Strategies

Since Canada declared its 200-mile limit on January 1, 1977, responsibility for annual stock assessments and management advice related to sealing off eastern Canada has been assumed by the Marine Mammals Subcommittee of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC). To date, international consultation between scientists from Canada, Norway, and Denmark has continued through an Ad Hoc Working Group on Seals within the Standing Committee on Research and Statistics (STACRES) of the ICNAF. Canada's decisions regarding exploitation of seals within its 200-mile jurisdiction, and this includes the bulk of the annual catch, are now discussed with the European Economic Community on behalf of Denmark (Greenland) which also declared a 200-mile limit on January 1, 1977. Decisions regarding Norway's participation in the annual seal hunt within Canada's extended jurisdiction are subsequently discussed by the Canada/Norway Sealing Commission.

This complex management structure will change in the near future with the creation of the Northwest Atlantic Fisheries Organization (NAFO) to replace the ICNAF. NAFO will provide a mechanism for "multilateral co-operation" (Anon. 1978) in the new era of extended national fisheries jurisdiction. It is not known what effect the granting of home rule to Greenland on May 1, 1979 will have on fisheries management deliberations, including those which affect harp and hooded seals.

Harp seals

A summary of management quotas and resulting catches is given in Lavigne et al. 1979. The current total annual catch (TAC) of 170,000 for the spring hunt off eastern Canada, with an additional allotment of 10,000 to account for the Canadian Arctic and West Greenland summer fisheries, is designed to permit the population to increase towards the stock size required to produce the maximum sustainable yield (MSY) (Fisheries and Environment Canada 1978a).

Hooded seals

Quota management was first introduced for Northwest Atlantic hooded seals in 1974 (Sergeant 1976) and the TAC for Canadian and Norwegian sealers has remained at 15,000 hooded seals per year despite at least two requests from the Canadian sealing industry to reduce the quota to 10,000 animals. Since the quota was introduced, annual catches at Newfoundland have averaged 12,000 and the quota has been achieved in only one year (1975) (ICNAF 1978b). The unregulated summer hunt off West Greenland appears to account for an additional 2,500 to 3,500 seals (ICNAF 1978b). During the last three years the proportion of adult hooded seals permitted in the catch has been reduced progressively from 10 to 7.5 to 5 percent of the catch (Fisheries and Environment Canada 1978a). It is claimed that the present management regimen will allow the stock to increase (Fisheries and Environment Canada 1978a).

Discussion

It is difficult to evaluate the results of any management program without a knowledge of its objectives. As with the management of most wild living resources, management objectives for seals in the Northwest Atlantic have not been specified in operational terms. The most commonly stated objectives for harp seals, initially outlined by the Scientific Advisors to Panel A (Seals) of the ICNAF (ICNAF 1976, Mercer 1977, Fisheries and Marine Service 1976), is that the stock be allowed to rebuild towards the MSY level. Although this appears to be the sole objective considered in stock assessments it is also stated that another management objective related to exploitation of harp and hooded seals is maximization of socio-economic gain to fishermen and to society over the long term (Mercer 1977, Dunn 1977). It is relevant that long term in this context apparently refers to a period of from 5 to 10 years (Fisheries and Marine Service 1976), and that these two frequently stated objectives may not be totally compatible (Gulland 1976). Nevertheless, the harp seal in the Northwest Atlantic is not the epitome of inadequate management that the controversy surrounding its exploitation (Lavigne 1978) might suggest. In reality, there are more and better data available on the biology of this stock than for almost any other exploited marine resource, and this includes a number of other pinniped species, whales, fish, and invertebrates. The management strategy based on these data also appears consistent with the management of these other resources. It remains to be asked whether this strategy is the best or the most appropriate which can be developed on the basis of available information for the long-term conservation, not only of the harp seal but also of the Northwest Atlantic ecosystem and the multispecies fishery it supports.

Certain biological characteristics of harp seals make it difficult to assess the effects of quota management since its introduction in 1971. Harp seals live for 30 years or more, require an average of four or more years to reach sexual maturity, depending on growth rates of immature animals, which in turn depend on food availability and intraspecific competition for food resources (Sergeant 1966, 1973a, 1973b). Female seals thus enter the breeding population to give birth to their first pup at an average age of five. As a result, it was initially predicted that the effects of quota management would not be reflected in the breeding population for several years (ICNAF 1971). It should not be unexpected that, to date, few empirical observations have confirmed that the population has begun to stabilize or even increase in numbers since the introduction of quota management. There is, however, some evidence of increased year-class survival from analyses of catch-at-age data (Sergeant 1978).

The conclusion that harp seal numbers are increasing at the present time is based on indirect estimates of abundance (Lett and Benjaminsen 1977, Winters 1978). There are reasons to suggest that these assessments may be optimistic in their predictions (Lavigne 1978). They contain tentative assumptions and conceal inevitable variability which is inherent in biological data. In some instances, when new data have contradicted earlier analyses, the data have been rejected as being anomalous (Lett and Benjaminsen 1977) and the more optimistic assumptions have been retained. The present management strategy is therefore based almost entirely on population models, complex hypotheses which remain to be verified by empirical data.

It is often noted that the harp seal is the second most abundant phocid seal, exceeded only by the unexploited crabeater seal (*Lobodon carcinophagus*) in the Antarctic (Mercer 1977, 1978). The statement is true, but somewhat irrelevant. Despite the uncertainty in estimates of population size and pup production, it is generally agreed that the stock has been reduced to levels well below that required to produce the MSY (Lavigne 1976b, Lett and Benjaminsen 1977, Winters 1978). The population has probably exhausted its ability to counteract the effects of further overexploitation through various compensatory mechanisms including density-dependent maturation and reproductive success. On this basis alone the stock would be classified as "depleted" by the U.S. Marine Mammal Commission (1976). Furthermore, estimates of MSY stock size for harp seals are usually generated by Schaefer-type models which assume that the MSY occurs at about 50 percent of the maximum or potential stock size (Lett and Benjaminsen 1977, Winters 1978). The harp seal, a typical *k*-strategist (Pianka 1970), might be expected, however, to produce its MSY at somewhat higher stock sizes as implied by McLaren (1977).

Since the MSY approach to assessment and management has obvious limitations (Larkin 1972, 1977, Talbot 1975, 1977, Holt and Talbot 1978), it may be more relevant to ask how far a phocid population can be reduced and still be safely exploited at levels close to the calculated sustainable yield. Eberhardt and Siniff (1977) concluded that a conservative approach to the management of pinnipeds might be to maintain them at levels above the MSY stock size. Clark (1976) also suggested that the MSY concept may only be useful if it is used to establish the lower bounds on exploitation. More recently Lett et al. (1978) demonstrated the problems of even trying to obtain a precise and accurate estimate of the MSY stock size for Northwest Atlantic harp seals. Thus although the Canadian government claims that it may decide to "maintain stocks at levels far . . . below those producing maximum sustainable yield" (Mercer 1977), there are few precendents to support such a position and a growing body of literature to caution against it (Doubleday 1976, Beddington and May 1977).

At the present time, the development of more realistic population models is constrained by the deficiencies in the available biological data base. Recognizing this, it would seem prudent to develop management policies which maximize the acquisition of new data (Gulland 1976). However, suggestions that harp seal pups be exploited "informatively," perhaps by trying to harvest all the pups in one year and protecting them the next (Allen 1975, Walters 1976) have not been attempted. Similarly, data potentially available from animals aged one and older that are killed in the hunt are not systematically collected by scientists and there is no requirement that the industry collect such data, despite the fact it might be in their own best long-term interests to do so. Research priorities continue to be established on a year to year basis. What is required is a long-term research program to monitor vital parameters, including age at maturation, fecundity, and, most importantly, age-specific natural mortality. Models used for management purposes assume uniform natural mortality for all age classes including young of the year, although there are few if any reliable data on natural mortality in young seals (Lett et al. 1978), and this may represent an optimistic assumption (Caughley 1966).

The paucity of available data places serious limitations on the development of appropriate management strategies for hooded seals. Although the reduction in the kill of older hooded seals is a conservative measure, it is difficult to defend the killing of any adult females at the present time. It is equally difficult to justify claims that the management regimen for hooded seals will allow the stock to increase (Fisheries and Environment Canada 1978a). Over-exploitation must still be viewed as a possible threat to hooded seals in the Northwest Atlantic (FAO 1976).

Harp and hooded seals represent only two exploited components in the Northwest Atlantic ecosystem (Lavigne et al. 1976). This ecosystem supports one of the largest international and multi-species fisheries in the world. Yet management of seals (and other fisheries) is still based almost exclusively on single species considerations. Except for the inclusion of density-dependent maturation and reproductive success in harp seal models, no obvious concessions have been made for ecosystem changes which have undoubtedly occurred in the Northwest Atlantic over the last 25 years. In 1976, the development of the capelin *(Mallotus villosus)* fishery, from 6,000 metric tons in 1971 to in excess of 360,000 metric tons between 1973 and 1976 was viewed as a possible threat to the harp seal (FAO 1976). In 1977, catches declined to less than 250,000 metric tons (ICNAF 1978c) and in 1978 the Minister of Fisheries closed the fishery because of small catches and the predominance of immature fish in the catch (Fisheries and Environment Canada 1978b). During this same period, nursing female harp seals examined in 1978 were found to have lower energy stores than a similar sample of seals obtained in 1976; the difference between the two years was equivalent to 40 days of fasting (Innes et al. 1978). Whether these two indications of ecosystem changes are related or coincidental is not known. Nevertheless they do suggest that ecosystem considerations should be incorporated into routine stock assessments and into the formulation of appropriate management strategies for seals and other marine resources. A reduction in capelin biomass could have a profound effect on the stock increases presently projected for seals, whales and cod, all of which consume capelin and whose population densities appear to be limited by food availability (Lavigne et al. 1976).

Other management problems include several non-biological considerations (Lavigne 1978). The objectives of Inuit and Greenlanders whose catches of harp and hooded seals are at least somewhat density-dependent, may not be satisfied because of the present depleted state of the stocks. Average annual catches of harp seals in West Greenland have declined from more than 22,000 in the 1940s to less than 7,000 in recent years (Kapel 1975, 1978). Similarly, the public controversy over the spring seal hunt off Labrador and Newfoundland, has apparently reduced market values for seal pelts in general. This has caused additional problems for Inuit attempting to sell pelts of several phocid species which they traditionally hunt (Wentzel 1978, Williamson 1978).

Although the public controversy surrounding the exploitation of harp seals focuses attention on this species, the problems related to the management of seals in the Northwest Atlantic are problems of a general nature which pertain to the management of all living resources. Present management objectives consider only the consumptive value of the resource, and seals are still viewed as property, a commodity to be exploited for economic gain. Leopold's (1970) concept of a conservation ethic is as applicable today to the management of seals in the Northwest Atlantic, as it was when first proposed as a general ecological philosophy over 30 years ago.

The Canadian government claims that it takes a balanced ecosystem approach to the management of marine resources in the Northwest Atlantic (Mercer 1977). This is clearly not possible; we have neither the data nor the expertise. We should accept now that we cannot yet manage living marine resources, and turn our attention to managing human activities in a way that will preserve, as far as possible, the diversity and complexity of ecosystems we exploit.

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Critical Shorebird Resources in James Bay and Eastern North America

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Introduction

Shorebirds, which include the plovers, turnstones, sandpipers, curlews, yellowlegs, dowitchers, godwits and phalaropes, form one of the most important components of the North American avifauna. As such, the protection and management of the habitats and resources they use assumes considerable importance in any serious wildlife management program on our continent. Shorebirds might be described as the ultimate migrants; they have always captured peoples' imaginations with their long distance movements, which take some species from the Canadian High Arctic to the southern regions of South America. During these migrations, the birds make use of widely separated, seasonally abundant food resources at intermediate stopover areas, where they are able to build up large fat reserves required for the next long distance, nonstop flight, which often takes them over an 'ecological barrier' where feeding or resting would not be possible. For instance, many eastern North American estuaries provide such critical feeding and resting areas where energy reserves are accumulated for a direct, trans-ocean flight to South America.

Shorebird populations are known to be affected by environmental changes and by man's activities. They are protected in Canada and the United States under legislation ensuing from the Migratory Birds Convention of 1916, and are one of the groups with which the Convention is specifically concerned and for which it was drawn up. Since receiving protection from hunting, which on a market scale was generally considered to have led to enormous declines of many species (e.g. Bent 1927, 1929), the Eskimo Curlew being the most notable example (e.g. Forbush 1912, Bodsworth 1955), many species have recovered numerically, though whether to their former abundances seems doubtful—and difficult to assess. The status of shorebirds is again threatened, through alteration of their habitat in many regions throughout their range. Coastal development schemes, both actual and proposed, affecting estuaries include tidal power projects, port facilities, hydroelectric projects, pollution, land reclamation, oil and gas projects and direct disturbance from human recreational use.

Knowledge of shorebird distribution and an understanding of the functional significance of a given area in the life cycle of the species concerned is obviously of basic importance in the identification of critical shorebird resources. With such highly migratory birds, this knowledge can clearly only be achieved effectively through work on an international scale. Since 1974, the Canadian Wildlife Service has carried out distributional surveys in James Bay and the Maritime Provinces of

Canada, and has collaborated with the Manomet Bird Observatory, Massachusetts, in organizing an international volunteer survey network to investigate shorebird distribution throughout eastern North America and to extend our knowledge in the Caribbean, Central America and South America. The picture emerging is that many individual species may depend on relatively few areas which are critical for supplying the energetic and nutritional needs of the birds during migration, and that the migration routes and resources vary considerably between the various species. In this paper, we review briefly some of the preliminary results that are being obtained, using both common and less numerous species as illustrations.

Materials and Methods

The Maritimes Shorebird Survey and International Shorebird Survey schemes involve a network of volunteer participants extending principally throughout the Maritime Provinces of Canada and the eastern seaboard of the United States, with additional observers in the Caribbean, Central America, South America, and interior areas of Canada and the United States (Figure 1). The Canadian Wildlife Service organizes counts in Canada and the Manomet Bird Observatory organizes those in the remaining regions. Participants are asked to adopt a clearly delimited study area in which shorebirds are regularly counted in a consistent manner during the period of autumn migration and into the wintering period where appropriate. Surveys in Canada occur once every two weeks, while those in remaining areas are carried out three times per month. Censuses are carried out either (a) near high tide to count flocks of roosting shorebirds, or (b) when shorebirds are concentrated on feeding areas at intermediate tidal levels. Weather, tidal data and other conditions affecting counts are also recorded. Direct counts are made wherever possible, though estimates are necessary for large numbers. Instructions and data forms are provided by the Canadian Wildlife Service and Manomet Bird Observatory.

Distributional data are presented using results from the 1976 survey season, involving 25 primary sites and 30 secondary sites in eastern Canada and a selection of 41 sites from the eastern and interior U.S., Caribbean, Central and South America (Morrison 1978a, Leddy and Harrington 1978) (Figure 1). Shorebird distribution is illustrated using the maximum count obtained for the species at each site during the season (Table 1). Clearly, not all sites of importance for shorebirds were covered during the 1976 season, and a fuller, more detailed picture will emerge when analysis of all years of the surveys (1974–1978) has been completed. However, representative sites in many regions were surveyed and the results indicate the relative distribution of different species and indicate the heavy reliance placed on favoured areas.

Aerial surveys in James Bay and Hudson Bay were carried out on 27–28 July 1976 in a single engine de Havilland DHC-2 Beaver aircraft equipped with floats, flying at an altitude of approximately 100–120 feet (30–36 meters) above ground level and an airspeed of approximately 100 miles per hour (160 kilometers per hour). Surveys were timed to coincide with high tide over as much of the coastline as possible to count roosting flocks.

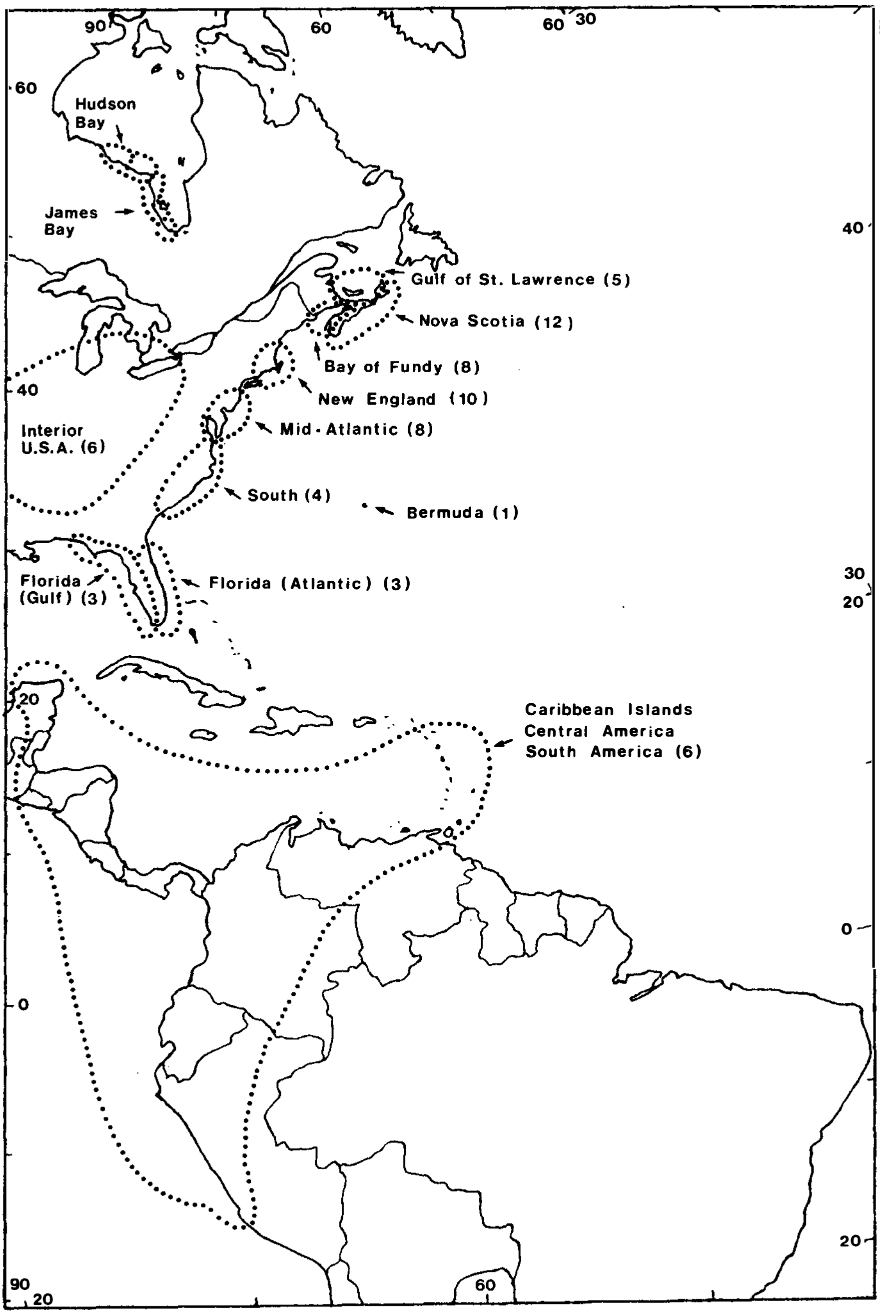

Figure 1. Distribution of survey sites at which shorebirds were counted during Maritimes Shorebird Survey and International Shorebird Survey operations in 1976. Number of sites surveyed in each is indicated (see also Table 1), and areas in which aerial surveys were carried out in James Bay and Hudson Bay in July 1976 are also shown. See "materials and methods" section of text for further details.

Table 1. Counts of shorebirds obtained during aerial surveys in James Bay and Hudson Bay and during Maritimes Shorebird Survey and International Shorebird Survey operations in 1976. See Methods section of text for details and Figure 1 for distribution of survey sites.

Survey		Number of sites surveyed	Semipalmated sandpiper	Red knot	Hudsonian godwit
Aerial Surveys: Ontario coastline					
James Bay:	south	—	7,477	4,247	1,111
	central	—	3,218	345	332
	north	—	1,973	1,518	618
Hudson Bay:	east	—	3,393	449	103
	west	—	808	779	1,482
		—	16,873	7,338	3,646
Maritimes Shorebird Survey					
Gulf of St. Lawrence		5,7[a]	591	5	13
Nova Scotia Atlantic coast		12,14	8,590	195	37
Bay of Fundy		8,9	317,405	305	54
International Shorebird Survey					
New England		10	38,072	3,989	60
Mid-Atlantic		8	16,429	2,976	33
South		4	273	27	0
Florida:	Atlantic coast	3	80	70	0
	Gulf coast	3	1	9	0
Bermuda		1	117	1	0
Interior U.S.		6	15,627[b]	17	3
Central America, South America Caribbean islands		6	5,562	47	2

[a]No. primary sites, no. secondary sites
[b]Total includes 15,410 at Cheyenne Bottoms, Kansas; 217 at remaining sites

Results

Distribution and Migration of the Semipalmated Sandpiper (Calidris pusilla)

The semipalmated sandpiper appears to be the most numerous shorebird in eastern North America. During autumn migration, by far the highest concentrations occur in the upper Bay of Fundy, where counts may exceed those in other localities often by as much as tenfold (Table 1). The most important single site appears to be Mary's Point, New Brunswick. The peak count of semipalmated sandpipers at this site in 1976 was 125,000, though in 1977 a peak of 350,000 was recorded (Morrison 1978b) and in 1975 observers estimated that the peak survey count of 200,000 birds was exceeded by 4–5 times over one tidal cycle at the end of July (Morrison 1976b). Farther south on the Atlantic seaboard, the birds concentrated in New England (Massachusetts, Rhode Island, Connecticut) and the mid-Atlantic (New York, New Jersey, Maryland, Virginia) states (Table 1) (Leddy and Harrington 1978).

Banding and measurement studies (Harrington and Morrison 1979) have recently led to a considerable increase in our understanding of the migrations of populations of semipalmated sandpipers from different parts of the breeding range. The species varies in size across its extensive breeding range, with the largest birds in the eastern arctic—northern Quebec and Baffin Island—and the smallest birds in western areas in Alaska. Measurement studies using data from museum specimens and live birds trapped during banding operations show considerable differences in routes used by these sections of the population during spring and autumn migration. In spring, birds from the western and central parts of the breeding range migrate northwards through the interior of the U.S. and Canada, whereas birds from the eastern Arctic follow a route up the Atlantic coast. In autumn, the westernmost breeders pass southwards again through the interior, and eastern birds use the Atlantic route, though the majority of the latter appear to stay somewhat to the north and east of their spring route. Many birds from the central breeding areas do not retrace their spring route through the interior but migrate eastward to the Atlantic coast (Harrington and Morrison 1979).

Banding results confirm that populations of semipalmated sandpipers using east coast estuaries are drawn from a wide section of the breeding range and that the estuaries serve as critical stopover areas where birds build up large fat reserves before a trans-ocean flight to South America or the Caribbean (Morrison 1977a). Color-marking studies carried out by the Canadian Wildlife Service have demonstrated that semipalmated sandpipers passing through major staging areas in James Bay disperse widely along the eastern seaboard, including the important areas in the upper Bay of Fundy (Morrison 1977b, 1978c,d). Other color-marking work has indicated that birds leaving the Magdalen Islands, Gulf of St. Lawrence, Quebec, and the Maritime Provinces take an oversea route to South America (McNeil and Burton 1973, 1977). This conclusion was supported by studies of fat deposition, which showed that semipalmated sandpipers (and other species) accumulated large enough fat reserves to fly nonstop from the Maritime Provinces to South America (McNeil and Cadieux 1972).

Distribution and Migration of the Red Knot (Calidris canutus)

The red knot is a species for which concern should be expressed. Its numbers were reduced drastically in the days of market hunting (e.g. Bent 1927), though considerable recovery has taken place since then. It is a long-distance migrant, generally occurring in large numbers in relatively few areas, with fairly specialized food requirements, and is sensitive to disturbance. Counts have suggested that the North American subspecies may number only a few tens of thousands, in contrast to the European wintering population which has recently been estimated in the range 400–600,000 (Prater 1976).

Aerial surveys have indicated that James Bay is a staging area of major importance for the red knot. In July 1976, over 7,300 red knot were recorded during an aerial survey of the Ontario coast of James and Hudson bays (Table 1). Up to 5,000 and 2,500 birds have been observed during peak migration periods at Longridge Point and North Point, respectively, on the southwest coast of James Bay.

These concentrations are generally much larger than those observed during counts on the east coast. The sum of the maximum counts observed during Maritimes and International Shorebird Survey operations in 1976 was 7,641, with highest recorded concentrations in southeastern Massachusetts (Monomoy Island, 2,500; Scituate, 900) and New Jersey (Great Egg Harbour, 1,400; Tuckerton, 800) (Table 1). Those few sites in Massachusetts and New Jersey thus accounted for 91 percent (55 percent and 36 percent respectively) of the red knot recorded on the survey schemes in 1976.

From the eastern seaboard, the autumn migration route appears to pass through the Guianas, where many make landfall after an apparent nonstop flight across the Atlantic ocean (Spaans 1978, Morrison and Spaans 1979). Few large concentrations of red knot have been reported on the north coast of South America. In September 1978, however, approximately 900 red knot were observed in the vicinity of Krofajapasi, Surinam, including 3 birds color-marked only 23 days previously in James Bay (Morrison and Spaans 1979).

Most red knot appear to move on to wintering grounds in the southern parts of South America (Argentina, Tierra del Fuego), where reports of up to 5,000 have recently been obtained (Devillers and Terschuren 1976).

Distribution and Migration of the Hudsonian Godwit (Limosa haemastica)

As recently as the 1940s and later, many ornithologists considered the Hudsonian godwit to be on the verge of extinction, owing to the very small numbers that were recorded anywhere in eastern North America. However, Hope and Shortt (1944) saw over 1,000 on the west coast of James Bay in July 1942, and Hagar (1966) reported that 3–4,000 could be seen during the course of an afternoon at peak migration periods on the southwest coast of James Bay. Hagar (1966) has admirably reviewed the evidence indicating that the Hudsonian godwit makes a direct, nonstop flight from staging grounds on the west coast of James Bay to South America, a distance of at least 2,800 miles (4,500 kilometers). This feat accounts for their scarcity along the eastern seaboard of North America and eclipses the rather better known example of the golden plover (*Pluvialis dominica*).

Aerial surveys by the Canadian Wildlife Service in James Bay and records from the shorebird survey schemes have confirmed the above distributional pattern and migration hypothesis. In July 1976, 3,646 Hudsonian godwits were recorded during an aerial survey of the Ontario coast of James Bay and Hudson Bay (Table 1). Up to 1,500 godwits have been recorded at North Point, and in early September 1974 an estimated 10,000 were present at locations north of the Albany River (unpublished data). In contrast, the maximum number observed at any east coast locality on the shorebird surveys in 1976 was 52, and the maximum counts from all sites totalled only 202 (Table 1). Dates of sightings of many of the observations on the east coast indicate that these may involve subadult birds or early migrants; few adult birds appear to interrupt their migration or land at intermediate areas. These results underline the outstanding international importance of the James Bay coast as an area in which the Hudsonian godwit accumulates the large fat reserves required to enable it to undertake the long, nonstop flight to South America.

Discussion

Studies of long-distance shorebird migrants have shown that many gain 50–100 percent of their pre-migration weight in fat reserves, and that such reserves would enable a number of species to fly nonstop from eastern Canadian estuaries to South America (e.g. McNeil and Cadieux 1972, Morrison 1975, 1977c). Even though staging areas may be used by large numbers of birds for a period of only a few weeks each year, they are nevertheless of critical importance to the survival of those populations.

Food resources, consisting principally of intertidal invertebrates, and suitable roosting areas in close proximity appear to be the two most important factors influencing shorebird distribution. Shorebird surveys and related food studies carried out by the Canadian Wildlife Service in James Bay (within the framework of a wider integrated ecological study of the coastline—for a general description see Glooschenko and Martini 1978) have indicated that shorebirds concentrate in areas of high invertebrate densities (unpublished results). Although such areas include perhaps only 20 percent of the James Bay coastline, the presence of long, undisturbed stretches of habitat contribute to making the area particularly attractive to birds, and the open nature of the shore indicates that any major development would probably affect long sections of the coast. The high shorebird concentrations occurring in the upper Bay of Fundy are also related to the availability of extensive mudflats containing very high densities of invertebrate prey (Hicklin and Smith 1977). Studies of shorebird feeding ecology and habitat utilization are being undertaken in James Bay and the Maritime Provinces by the Canadian Wildlife Service and in Massachusetts by the Manomet Bird Observatory. The availability of suitable roosting areas is also important in determining shorebird distribution (Furness 1973a,b, Elliot 1977). For instance, the northwest arm of the upper Bay of Fundy consistently supports considerably more shorebirds than the southeast arm, despite the fact that the latter has a much larger area (3–4 times) of intertidal mudflat and a longer (30 percent) coastline (Morrison 1976a, 1977a). Although geographical considerations and food resources no doubt influence this distribution (Morrison 1976a), the greater availability of good roosting sites adjacent to feeding areas in the northwest arm at locations such as Mary's Point, New Brunswick, may also be of underlying importance.

Any major environmental changes resulting either in direct displacement or disturbance of birds at feeding or roosting areas or in a deterioration in the productivity of the food resources on which the birds depend, could have adverse effects on shorebird populations far greater than might be inferred from the small numbers of birds present at the sites during most months of the year.

Knowledge of the distribution of a species on an international scale is essential in assessing the significance of a given area in the yearly cycle of the bird. The shorebird survey schemes are beginning to provide a coordinated, overall picture of shorebird migration in eastern North America and are proving of great value in identifying areas of major importance for different species. This approach has been equally fruitful in Europe (Morrison 1977c). The survey results are also showing that the migration strategies and routes used by various species are in many cases rather different from one another and that management requirements will also therefore be distinct for different species. Data are being obtained for some 35 species of shorebirds, including both long-distance migrants (such as those described above) and nongregarious, relatively scarce species such as the piping plover *(Charadrius melodus)* for which conservation concerns have been expressed.

Although data analysis is far from complete, survey results indicate that there is only a limited number of sites of major international importance for shorebirds in eastern North America. The majority of such sites occur in coastal areas. Inland locations which were surveyed in 1976 generally held much lower concentrations of shorebirds, with the notable exception of Cheyenne Bottoms, Kansas. Shorebirds using inland routes apparently gravitate to relatively few oases of habitat characterized by abundant food supplies and resting areas. Sites on the Great Lakes do not appear to play a major role in autumn shorebird migration. Some areas along the St. Lawrence estuary, however, support large numbers of shorebirds.

Whereas our understanding of shorebird migration in North America is increasing rapidly, less is known about areas on the wintering grounds in South America, where many shorebirds spend the greater part of the year. We are attempting to extend the survey network in South America, and to encourage individuals, groups and governments to undertake or support work which will identify important shorebird areas on that continent. It is desirable also that initiatives should be undertaken by the Canadian and U.S. governments to encourage South American governments to adopt protective legislation for shorebirds where it may be needed.

Effective conservation or management of shorebirds clearly depends ultimately on protection of both the birds and their habitats throughout their range. It would appear essential that regional assessment of proposed developments should be coordinated on a much wider scale than is presently the case. With development of coastal areas proceeding for a variety of purposes over a wide geographical range, it would be folly to allow widespread creeping erosion of shorebird habitats to lead to a situation where a few remaining important areas were threatened simultaneously with no alternatives left for the birds to use. The identification of multiple threats to coastal habitats and the protection of internationally important areas through public or private organizations are goals to which we must aspire.

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The State of Knowledge of the Porcupine Caribou Herd

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Introduction

Some major problems and complications emerge during analysis of the state of knowledge of the Porcupine Caribou. Perhaps foremost, is the fact that the herd is truly international, with continuous ranges in Alaska, the Yukon and the Northwest Territories. Its international status complicates research and management. Another complication is that of the various Native claims now being made on the lands ranged by the animals in Canada, or claims which have been finally or partly settled in Alaska. Perhaps the greatest complication, in the short term, was the discovery of gas and oil at Prudhoe Bay and the intensive search for more throughout most range of the herd. The development of oil wells, haul roads, pipelines, airstrips and activities associated with exploration have presented ecological problems perhaps unprecedented in northern North America. They have stimulated environmental action at all levels of government, and in the public sector. The Porcupine Caribou Herd and its range have been at the center of the activity.

A separate problem has been the construction of the Dempster Highway from Dawson City in the Yukon to Fort McPherson on the Peel River, joining the MacKenzie Highway and bisecting the primary winter range of the Porcupine Caribou Herd. The Dempster Highway is a paradox among recent environmental crises in the North. On the one hand the Canadian government required oil companies and others to be subject to stringent ecological enquiries and regulations; on the other hand it proceeded to build a road with perhaps far greater long term potential for environmental damage than anything developed by industry, and with no preliminary environmental studies.

It is unfortunate that the enormous burst of ecological investigations during the first half of the 1970s came so rapidly and from so many sources. Many of the resulting reports tend to be long on description and short on creative research and interpretation. Some of the more expensive work is also redundant. Thus, several agencies followed the annual movements of the Porcupine Caribou simultaneously in some of the years 1971–78. From 1971 to 1975 particularly, the movements and distribution of the animals were recorded in excruciating detail. The information would be much more valuable if it had been spread over a longer period of time or if a wider range of research had been undertaken. In retrospect, it seems apparent that research on the Porcupine Herd would have benefited greatly, and our knowledge of the herd would have been further advanced, if the activities had been coordinated through some type of international committee. The *ad hoc* Porcupine Caribou Committee, established for over a year, and having representation from Canadian and United States agencies with management responsibilities for the herd and its rangelands, now serves in a research advisory and coordinating capacity. It presents a useful model for the permanent establishment of an international committee to coordinate and guide future research.

History of the Porcupine Caribou Herd

Some sections of the northern Yukon and adjacent Alaska, including much of the current range of the Porcupine Caribou Herd (Figure 1), were not glaciated during the Pleistocene. MacNeish (1963) thought that man and caribou both were present in the Yukon at least 4,000 years ago. Subsequent discoveries in the Old Crow basin may take human occupation of the area back at least 34,000 years, and caribou remains are even older (Irving 1968, Irving and Harington 1973, Harington et al. 1975, Harington 1977 and 1978, Morlan 1977). While interpretation of the artifacts ascribed to human occupancy remains in question among anthropologists, caribou remains are among the most common of mammals from Yukon Pleistocene deposits, some going back at least 54,000 years ago (1978).

In contrast, historic knowledge of the animals extends only about 150 years to the Franklin expedition of 1825–27, when a few animals were killed for food (Franklin 1828). The systematic collection of scientific data on the Porcupine Caribou is even more recent. While biological collections and excursions onto their range were made earlier, we date the first attempt at informal but systematic international collaboration from 1952 (Munro 1953). That particular program was aimed primarily at enumerating the herd and was short-lived, but it did stimulate continued, if sporadic, research and inventory programs in both Alaska and Canada.

The species, *Rangifer tarandus,* has been the subject of numerous intensive research efforts, and innumerable individual studies, particularly since 1948. The Porcupine Caribou Herd has, however, been almost the last of the major herds to come under intense and systematic scrutiny by wildlife biologists.

The Caribou Range

General knowledge of the component parts of the range of the Porcupine Caribou Herd is available. The area of the range is known (i.e. Roseneau and Curatolo 1976) and there have been some detailed studies of geology and soils (Hettinger and Janz 1974, Reid and Calder 1977). The topography has been mapped and described, initially perhaps for air navigation, but also to the benefit of the wildlife investigator (i.e. Reynolds 1976, Surrendi and Debock 1976). The climate is known, but primarily from stations peripheral to the caribou range where the animals are found for only short periods (Brown et al. 1975, Reid and Calder 1977, Oswald and Senyk 1977). It must be inferred that some aspects of climate, for example snowfall, temperature and wind, would be locally influenced in many places by highly varied topography. There is a need for more detailed information of snow; its pattern of accumulation, density, hardness and seasonal meltoff.

The flora (Hulten 1968 and 1973, Rowe 1972, Oswald and Senyk 1977) and fauna (Preble 1908, Hanson 1972, Watson et al. 1973, Youngman 1975, Reynolds 1976) of the range have been described by experts working in both Canada and the United States. Some aspects of those components, however, hold particular relevance to caribou, especially food supplies and predators, and have not been adequately studied for management purposes. No comprehensive mapping of the vegetation types of the Porcupine Herd range has been done except locally on portions of the range in Alaska (i.e. LaPerriere 1976, Nodler et al. 1978). Additional studies of range vegetation have been initiated in Alaska and the Yukon. There is a need for detailed vegetation maps of the entire range, and assessment of the relative values of vegetation types for caribou as a basis for making land use decisions.

Food Habits and Range Studies

The general feeding behaviour of caribou has been described (i.e. Courtright 1959, Pruitt 1960, Kelsall 1968, Skoog 1968). This includes the annual chronology of food preferences, analyses of diet, and several studies of various quantitiative aspects of feeding (Klein 1970a and 1970b, White et al. 1975, Thing 1977). Most studies have not been conducted on the Porcupine Caribou specificially, and it would be of interest to know in greater detail the pattern of seasonal forage selection pursued by those animals.

Recent work in both Alaska and Scandinavia has shed more light on the question of the ability of caribou to feed selectively for forage of high quality (Skogland 1975, Klein and White 1978, Roby 1978). Movements on the summer range appear to be correlated with phenological progression of growth of forage plants and its relationship to forage quality. That, however, is complicated by the effects of insect harassment, and by movements to and from insect relief areas, which determine time available for feeding. White et al. (1975) have pointed to the importance to caribou of maximizing biomass intake, in lieu of selectively feeding for quality, when insect disturbance greatly limits available daily feeding time. The summer dietary regime, and factors which influence it, are obviously of primary importance in determining growth of young and condition of the animals going into winter, and ultimately calf survival and herd productivity. Additional information is needed on the bioenergetic relationships of caribou to their food supply on a year round basis.

Radioactive fallout and pollution of caribou food supplies, and secondarily the appearance of radionucleides in caribou-dependent Native peoples and wolves have had particular study in Alaska, and have been monitored to some degree in Canada—but not specifically in relation to the Porcupine Caribou Herd (Hanson and Palmer 1964, Palmer et al. 1965, Hanson 1967, U.S. Public Health Service 1968). It has been shown that with institution of below-ground nuclear testing the radioactive burden of caribou foods (mostly in the form of caesium-137) has declined continuously. While both caribou and the people and wolves who eat them still carry large radioactive burdens, they now tend to be approximately 20 percent of the permissible load under international standards. The constant relationship between the radioactivity levels of lichens, caribou and wolves does, however, provide a basis for estimates of feeding rates of caribou and of wolf predation on caribou (Holleman 1976).

The effects of other pollutants, particulary sulphur dioxide, on lichens have had attention as well (i.e. Skorepa and Vitt 1976). Experience from the Soviet Union

(Aralova 1975) and other areas raises concern over the possible impact on lichen ranges of large scale petroleum processing facilities which may be necessary in association with exploitation of petroleum reserves. Luick et al. 1976 have examined the effects of ingested crude oils on reindeer. Much detailed work remains to be done in the general field of caribou food and polluting substances.

There have been many quantitative studies of caribou and reindeer ranges (i.e. Courtright 1959, Scotter 1964, Kelsall 1968, Skoog 1968, Klein 1968, Davis et al. 1978). Again, however, specific studies of the Porcupine Herd ranges are only now being developed. The effects of fire on forested caribou ranges have been hotly debated (Scotter 1964, Bergerud 1974, Miller 1976), but present concepts tend to view the northern boreal forests as a fire-dependent ecosystem in which caribou evolved (Kelsall et al. 1977). Fire may be essential for recycling of nutrients and continued productivity in northern forests, but it can result in massive short term losses of caribou forage. Long term study of recovery following fire of differing vegetation types, under differing burn characteristics and site conditions, is required as a basis for future decisions on fire management policy. Viereck (1973), among others, has made some relevant contributions in Alaska.

Migration and Movements

At the time of writing, a bibliography being constructed by Kelsall contains over 210 citations pertaining to migration, movements and seasonal distribution of the Porcupine Caribou Herd. Foothills Pipe Lines (Yukon) Ltd. (1978a and 1978b) have provided the most recent and comprehensive summary of movements in relation to winter range use and spring migration spanning 1971 to 1978. Some other major summary documents are those of Calef 1974, Doll et al. 1974, and Roseneau and Curatolo 1976. A bit of serendipity arising from recent studies was the detailed examination of the remains of many fences and corrals used in the past by Indians to capture or aid in the killing of caribou. The general distribution and alignment of the fences strongly suggests a caribou distribution and movement pattern similar to that prevailing today (Warbelow et al. 1975).

As in virtually all caribou populations that have been studied over a period of time, some annual variation in routes of migration and in the precise locations of calving, summer and winter ranges have been noted. As with other caribou, calving grounds of the Porcupine Herd have been the most constant distributional factor. In addition to geographic variation, there also tends to be variation in the timing of major annual movements, and that too conforms to what is known of other caribou populations. Climatic factors in particular, such as early winter snow, or deep long-lasting snow in spring, may hasten or inhibit movements. For example, during the current winter (1978–79) huge segments of the herd have remained in Alaska and further north in Canada than is the usual pattern (J. Russell, personal communication). That is apparently associated with early arrival and accumulation of winter snows.

Herd Dynamics

Skoog (1968) and LeResche (1975a and 1975b) summarized, or referred to, most of the early studies which provided quantitative data on the dynamics of the Porcupine Caribou Herd. The most complete and recent source documents are

"An aerial photo-estimate of the 1977 Porcupine Caribou Herd population" by Bente and Roseneau (1978), and a report on the sex and age composition of the Porcupine Caribou Herd by Davis (1978).

LeResche, and Bente and Roseneau provide data on two censuses of the Porcupine Caribou Herd made by an aerial photo, direct-count-extrapolation technique in 1972 and 1977. Those counts provide data not only on herd size, which was remarkably close to 105,000 animals on both occasions, but also on age and sex composition. Davis (1978) pointed out that the number of adult females in the herd was substantially reduced, according to the data, at the time of the last census—a matter of considerable concern.

The air photo technique for census appears to be the best method available at present, but its shortcomings are immediately recognized when one considers that Bente and Roseneau (1978) put confidence limits of ±28,000 animals on their population estimate of 105,000. Confidence limits of that magnitude are inadequate for year to year management of the herd. Even with annual censuses, it could take years before major changes in population numbers were apparent with a high degree of certainty. Obviously, knowledge of the approximate herd numbers must be supplemented with other indices of population welfare.

A major problem for management of the Porcupine Caribou, and for all other large or wide-ranging caribou herds, is securing adequate age and sex composition counts. There are many spot segregations in the literature, particularly during Mackenzie Valley Pipeline studies in the early 1970s. In a majority of cases, however, it is not certain that segregations are representative of the herd as a whole (Klein and White 1978). Exceptions to that criticism may be found among cow/calf ratios. Even there, some of the best reports may be misleading. Thus Davis (1978), in discussing data from 1977, points out that "The calf/cow ratio observed during November (47.4/100) was higher than that observed in July (38.6/100), an inconsistency which could have been due to a number of factors." Recent assessment of composition counts for Alaskan herds points up the difficulty in obtaining unbiased counts (Doerr 1979). It is now apparent that at no season of the year are caribou randomly mixed by sex and age, and that sex and age ratios may vary locally and substantially with group size, stage of migration, and forage components present. Estimates of herd sex and age composition must be based on well planned, systematic stratified sampling and prior knowledge of distribution patterns.

It has become usual to attempt censuses when caribou form massive aggregations just following calving. Unfortunately, one is seldom certain what proportion of the bulls and nonbreeding cows are with the cows and calves, and it is sometimes impossible to establish what proportion of the herd has been censused. Research is continuing to refine air photo techniques and hopefully overcome the above shortcomings. Prior to 1968, censuses were generally attempted during the winter months (i.e. Kelsall 1968, Skoog 1968). A winter census has the advantage of viewing the animals against a snow background where they are readily seen, and where it may be possible to ensure that all major components of the herd have been found and enumerated by assessing the tracks, trails and feeding areas which stand out clearly. Age and sex ratios are not as easy to determine in winter, and the advantage of snow background may be lost if the animals are in either a canopied or close-growing forest.

Data relating to total numbers and to age and sex ratios are as thoroughly known among the Porcupine Caribou Herd as among most other large free-ranging herds. Because of their questionable accuarcy, the data still leave much to be desired and improved survey techniques are needed.

The literature suggests that the herd diminished within recent historic times from numbers much larger than at present (Skoog 1968), but there is some question as to when and how that reduction in number occurred. Skoog suggested that it was partially due to emigration westward, and also eastward across the Mackenzie River. The latter seems most unlikely. The only documented case (Porsild 1945) of the animals having crossed the Mackenzie Delta (in winter 1931–32), gives no indication that they did not return to the west. If losses to emigration are not well known, at least two possible cases of substantial augmentation of the herd by immigration of caribou from the Fortymile Herd are reported (Skoog 1968, LeResche 1975a, Davis et al. 1978), including a large movement in 1964. Unfortunately, it cannot be confirmed whether those animals returned to their native range or remained with the Porcupine Herd. With recent advances in methodology for determination of genetic variation between animal populations it may now be possible to apply those techniques to the Porcupine and adjacent herds to determine the significance of past exchanges between herds.

Hunting losses have only been documented on a rangewide and systematic basis on a few occasions in recent years. However, losses (including crippling losses) seem to be generally less than 5 percent of total herd numbers per year (LeResche 1975b, Surrendi and DeBock 1976). The literature suggests (Anderson 1913) that there was a great slaughter among the Porcupine Caribou, and other herds, during approximately 20 years around the turn of the century on the part of wintering whalers. That factor may be discounted considerably, because caribou do not normally winter near the coast, and the annual loss to whalers from the range of the Porcupine Caribou Herd may have been relatively small. Losses to predation are not known with precision, but are generally assumed to be approximately 5 percent per year, a figure frequently used by caribou biologists but having no solid basis (i.e. Kelsall 1968). Losses to parasitism and disease are not thought to be large—no unusual occurrences involving those factors have been recorded. There is, however, increasing evidence that under dry, warm summer conditions insect harassment can lead to substantial decreases in metabolic condition and heavy infestations of skin warbles and nasal bots (White et al. 1975, Skogland 1975, Davis personal communication).

The matter of predation, mainly by wolves but likely involving grizzly bears and other predators on the calving grounds, is overdue for intensive scrutiny. It is particularly relevant in view of the new concepts of the impact of predation resulting from efforts to construct mathematical models of caribou population ecology (Walters et al. 1975, Haber 1977, Haber et al. 1977, Bergerud 1978 and Davis et al. 1978). It has been suggested, in particular, that the activities of predators on calving grounds may be the single most important factor controlling caribou populations. Bergerud (1978) goes further than most and suggests that in some instances natural predation alone may be sufficient to create a catastrophic decline in caribou numbers. Those conclusions about the role of predation, however, assume relative constancy of other factors, such as levels of nutrition, snow conditions and human harvest; factors which may also vary widely (Gaare et al. 1975, Klein and White 1978).

Factors Affecting Movement and Behavior

The Porcupine Caribou Herd has been relatively undisturbed by extraneous human influences. Those factors which have affected their movements and behaviour, until recently, are ones that would normally occur in the environment. They include variations in topography, climate, the existing regime of wildfire, insect infestation and predation, including Native hunting. Studies of the influences of those factors have been primarily on caribou and reindeer herds elsewhere in North America and Eurasia.

Recent studies have been preoccupied with the possibilities for disturbance and major disruptions of normal movements and behavior which might be caused by major engineering developments of various sorts, and by increased human use of caribou range. Klein 1971 and 1974, Urquhart 1973, Child 1973 and Miller and Gunn 1977 are among those who have indicated the sorts of responses caribou and reindeer will make to various forms of artificial disturbances.

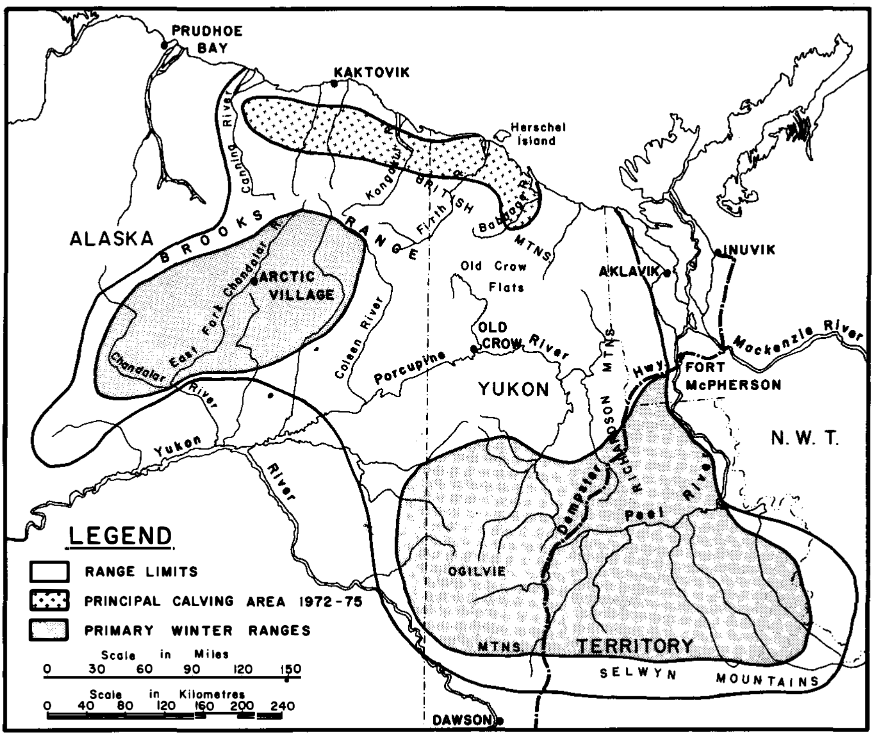

Figure 1. The range of the Porcupine Caribou Herd showing approximate limits since 1971, two areas of primary winter range used between 1971 and 1978 and primary calving area used between 1972 and 1975. Areas adjacent to that shown have been used for calving, and much of the total range has been used occasionally in winter.

The primary concerns under the general topic of human disturbance, in rough order of priority, are the following.

1. The Dempster Highway which runs from Dawson to Fort McPherson and bisects the southeastern winter ranges of the Porcupine Herd (Figure 1), providing increased access for hunting, and disturbance from traffic and related activity.
2. A proposed pipeline to carry gas from the Mackenzie River Delta to southern Canada which would parallel the Dempster Highway over much of its route.
3. Additional oil and gas exploration and development, including the construction of seismic lines and the intrusion of a good deal of varied human activity on winter and summer ranges and migration routes.
4. The possibility of electric generating stations with transimssion lines and associated haul and inspection roads, to service the pipeline and other developments in the range of the Porcupine Caribou Herd.
5. The possibility that major oil or gas lines may be constructed from new oil or gas fields, taking routes that will traverse the range of the Porcupine Caribou Herd.

Those items all have potential for doing great environmental damage, or for diverting caribou movements or restricting their range. Traffic and other activities on the Dempster Highway would cause disturbance which experience elsewhere suggests might increase over a long period of time. Vehicles moving along a highway have been shown to interfere with migration, to disrupt feeding on winter ranges (Klein 1971), and to interfere with movement and range use by cows with calves during summer (Roby 1978). Ancillary activities might provide even greater cumulative disturbance. Unless suitable regulations are established and enforced, one would expect that human hunting from the highway would increase with time. Light aircraft would certainly use the highway as a line of visual recognition in low flying, particularly in adverse weather, between the Yukon and northwestern parts of the Northwest Territories. Natural predators, particularly wolves, would quickly learn that the highway provides easy travelling and a topographic aid for their particular brand of hunting (Roby 1978). A lateral pipeline added to the highway would require spur roads for the purpose of pipeline inspection, and for the servicing of compressor stations. There would probably have to be manned supply depots of various sorts for emergency use by traffic and for normal purposes of securing gasoline, food and other supplies. There is ample evidence from Alaska, Scandinavia and the Soviet Union that major transportation routes through caribou or wild reindeer range have had long term adverse effects (Klein 1973, Villmo 1975, Cameron and Whitten 1977).

In addition to direct and obvious indirect effects of disturbance there are more subtle influences. Biologists are only now coming to grips with metabolic and physiologic stress. Assessment of disturbance and stress on wild caribou to date has been relatively crude and subjective (Geist 1971 and 1975), although some base lines are being established (White and Yousef 1978). Metabolic losses caused by harassment by over-snow vehicles, by low flying aircraft, or by disruption or diversion of migration patterns have yet to be accurately measured. The potential for costly caribou losses from causes of that sort is high in the Porcupine Caribou Herd, since winter range studies from 1971 suggest that nearly half the entire herd generally winters south of the Dempster Highway (Foothills Pipe Lines (Yukon) Ltd. 1978). It appears that components of the herd may suffer physiological stress despite the most careful management, unless they abandon nearly half their winter range. Losses could extend to reduced reproduction or even death as has been the case among domestic reindeer in the Soviet Union (Zhigunov 1968).

Wilderness Reserves

It has long been advocated that some or all of the range of the Porcupine Caribou Herd (Figure 1) should be set aside as a wilderness park or reserve (Hughes 1974, Laycock 1976). The concept has various interpretations but the ideal seems to be a huge international wilderness, spanning from approximately Prudhoe Bay in Alaska east to the MacKenzie River Delta in the Northwest Territories, and from the Arctic Ocean south to the extremities of the usual winter range of the Porcupine Caribou. The concept generally excludes major industrial activity, and minor intrusive activities that would have disturbing effects on caribou. It would permit Native people resident in the area to maintain their traditional way of life.

The concept has merit when viewed from the context of assuring the future well being of the Porcupine Caribou Herd. However, problems are immediately apparent. The international character of the proposal has yet to be resolved. The United States has established a wilderness reserve in Alaska, but Canada is just now acting to establish something similar in the Yukon and Northwest Territories. The land area involved is enormous, and it is unrealistic to expect that the entire range of the Porcupine Caribou Herd could be preserved as pristine wilderness, particularly with the Dempster Highway in operation.

Among other problems on the Canadian side of the border is the matter of Native land claims. All of the range is claimed as traditionally used land by one Native group or another. Furthermore there is no consensus on what constitutes traditional Native rights. In the strictest sense of the word, Native people might be expected to maintain a relatively primitive existence. The people living on the range of the Porcupine Caribou Herd, however, can scarcely be expected to ignore the sorts of technological advances that will inevitably occur as the decades roll by, or to discard the modern weapons and other items that they are now using—including over-snow vehicles and aircraft.

In spite of these "realities," or perhaps because of them, we urge the establishment of a reserve in Canada to complement the Arctic National Wildlife Range, which has already been established in Alaska, to encompass the entire calving area and summer range of the Porcupine Caribou Herd. The winter range, equally worthy of protection, should be subject to land use regulations that require impact assessment and evaluation for developmental activities which can be refused if loss of environmental values appears too high.

Summary

Our assessment of the state of knowledge of the Porcupine Caribou Herd has been necessarily brief. The topics chosen are biased toward their relevance to management.

The history of the herd has been well documented for the past decade, and moderately well documented for the past three decades. Historical information extends back about 150 years. The pre-history of man and caribou on the range of the Porcupine Caribou Herd is the subject of current intensive archeological investigation which carries caribou occupation of the area back 54,000 years or more, and may also greatly extend the record of human occupancy.

In general, the range of the Porcupine Caribou Herd and its component parts is well known, although knowledge of local areas and local phenomena (such as climate and characteristics of snow cover) leave much to be desired under some circumstances. Range studies and food habits relating directly to the Porcupine Caribou Herd are not far advanced, but much can be deduced through analogy. Although it seems unlikely that herd numbers are limited by range or food at present, the Dempster Highway and possible ancillary activities do have potential for separating the herd from nearly one-half of its principal and usual winter range. Additional emphasis in future research should be placed on mapping the vegetation of the range and assessing its productivity and the quality of vegetation types for caribou. That should also include long term monitoring of the recovery of plant communities following fire. Other range relationships which require further research include: (1) the relationship of available plant biomass to forage intake rates and the frequency and duration of feeding, (2) the relationship between grazing impact and plant primary productivity, (3) mechanisms of selection and factors governing selection of forage and habitats by caribou and (4) the influence of snow in affecting food availability and energy expenditures in feeding. Although the need for more information on those topics is not specific to the Porcupine Caribou, it is a prerequisite to a comprehensive approach to their management. Variations in range relationships unique to the herd will require specially directed research efforts. A case in point is the definition of the characteristics of caribou calving grounds which has not been dealt with adequately in other areas. While generalizations can be made from empirical evidence, they do not constitute an adequate basis for decision making regarding land use practices which may impinge on calving.

Migration and movement have been studied exhaustively since 1971. Areas of major seasonal use, migration routes and chronology of movement are well known. Like most caribou, the Porcupine Herd is, in general, extremely regular in its annual movements but, for purposes of prediction, there is sufficient annual variability so that generalizations would not serve for most year to year management purposes. Many of the factors affecting movement, and behavior associated with movement, are recognized and have been studied among other caribou, if not specifically among the Porcupine Herd. Much remains to be learned, however, about the specific effects of certain stimuli on caribou movements. Included are such factors as snow characteristics, human disturbances, the effects of condition of the animals and population size.

The state of the art as regards census, and age and sex determinations, is as good as among most other large caribou herds, but it is still deficient and will not yet serve for year to year measurement of subtle changes in total numbers, or in age and sex ratios. We consider improvement in the methodology of gathering census, and age and sex information to be one of the top priorities. We also consider that improvement in the systematic annual gathering of hunter kill data is an urgent need. The effect of predation on the herd requires study, and may be urgent. Some highly qualified people who have reconsidered the matter of wolf and bear predation on caribou, based on experience in other parts of North America, are now crying havoc with all the vehemence of the old time bounty hunter. There should be great and unrelenting concern over the possibility of adverse primary, secondary and even tertiary effects on the caribou herd from the development of transportation corridors and industrial efforts, some of which are already in place or predictable. The disturbance effects of the Dempster Highway, in particular, should be the subject of continued studies, and the effects of physiological stress on animals under a wide variety of conditions have been overlooked for altogether too long.

Successful management of the Porcupine Caribou Herd is dependent upon filling many of the gaps in our knowledge about the herd and about caribou in general. The conduct of research relating to the herd, and to the development and implementation of management guidelines, are in turn dependent upon close cooperation and collaboration between Canada and the United States.

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The Future of International Wildlife Conservation: A Federal Perspective

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David Munro, the Director General of the International Union for the Conservation of Nature and Natural Resources said in his speech at the opening session of this Congress that during the last 25 years North American conservationists have failed to "pass on the message" of environmental conservation to foreign countries where it is so badly needed. My talk today addresses how the federal government is " passing on the message" now and how we hope to do so in the future. This talk is in a sense a bureaucratic one; the type given by government scientists after the rueful day they discover that they have published the last of their original data. The idea, however, of carrying the message is an important one for North Americans from the U.S. and Canada because between our two countries we have more managers of wildlife and living natural resources than the rest of the world combined.

Dr. Munro's talk was important from another aspect as well because it illustrates the change that has occurred in the conservation movement both here and abroad. The urgency and power of the conservation message is the same as it was during the well-publicized period of the early seventies but the tone is more professional, more oriented to objectives, and the people more at ease in working with governments rather than against them. The recent publication of the *Twenty-ninth Day* by Lester Brown (1978) is a good example of what I mean by a changing perspective. The book deals with population growth and resource use under the pressure of this growth. The book contains facts and analysis on current population figures, growth rates and demography. It discusses the land, water and living resource uses predicated on these facts. It describes in a calm, professional way the same topics that Paul Erlich's *Population Bomb* (1968), written a decade earlier describes, but without the emotionally charged context.

In the past decade within the environmental movement in North America many of the spontaneously generated groups of the early 1970s, dedicated to a single species or to a single cause, have now fallen as victims to the new economic realities or have been consumed by their own emotional fires. This same consolidation and refocusing has also occurred within those groups interested in the environment beyond our borders. Within the last year we have seen a great decrease in international environmental activism, even from such traditionally active organizations as the National Audubon Society and the Sierra Club. From my perspective, neither of the organizations now plays a major role in the broader international issues, negotiations, and conventions, or in the government process as it once did. It is ironic that this retrenchment comes at a time when government itself, after prodding from private organizations and its own recognition of the needs, has begun to move with what the poet Francis Thompson called "unhurrying chase and unperturbed pace." Loosely translated, this means that we are now stumbling along toward useful international conservation programs.

Less than two years ago the U.S. Fish and Wildlife Service moved from a general implementation of Section 8 of the Endangered Species Act of 1973 to more specifically directed activities within international endangered species programs. An Office of International Affairs was set up within the Director's Office in Washington and a small professional staff hired to coordinate and initiate implementation of Fish and Wildlife Service programs. About a year later the Deputy Assistant Secretary for Fish, Wildlife, and Parks, at Mr. Herbst's request, was analyzing the future direction and goals of the international programs of the National Park Service, Heritage Conservation and Recreation Service, and the U.S. Fish and Wildlife Service. The policy decision was made that, in light of President Carter's Environmental Message of 1977, we would concentrate on the Western Hemisphere. The President had directed that the Secretary of the Interior implement the Convention for Nature Protection and Wildlife Preservation in the Western Hemisphere signed in 1940. This broad treaty is general in substance but contains an environmental ethic parallel in thought to that of Aldo Leopold. The treaty has been signed by almost all Western Hemisphere countries, with Canada, Surinam and Honduras being the major exceptions. Canada has expressed interest in the treaty and the U.S. Fish and Wildlife Service is providing information. At President Carter's invitation, the Organization of American States (OAS) will hold a ministerial meeting in Washington, D.C. next year to examine the Western Hemisphere Treaty and update it as necessary, given the experiences of the last 40 years. It is generally felt that the basic text needs little change but implementation has, until recently, been weak or nonexistent. During the past year the OAS has hosted three preparatory meetings for the Washington ministerial meeting. The first, in Argentina, was on marine mammals, the second, in Caracas, on professional training and education and the third, in Costa Rica, on parks and protected areas. A fourth meeting on Western Hemisphere migratory species will be held in Panama in June. The final preparatory meeting on legal aspects of the Treaty will take place in the fall of 1979 in Washington, D.C. I should emphasize that, while this activity was a U.S. Presidential initiative of two years ago, the meetings have been organized and run by the OAS and attendance of experts is by invitation of the OAS.

Within the Western Hemisphere framework, the Fish and Wildlife Service has increased its efforts in bilateral cooperation for wildlife conservation south of our border whenever we are requested to do so by a Western Hemisphere government. Our largest program is with Mexico under a U.S.–Mexico bilateral agreement on wildlife conservation. The cornerstone of the agreement is the U.S.–Mexico Migratory Bird Treaty, but the agreement goes beyond bird species to encompass a wide variety of species and management activities.

The Mexican program is a good example of the way we have attempted to work overseas. The program is federally directed in a joint manner with the Fauna Silvestre of Mexico and annual meetings alternate between the two countries. Nongovernment organizations play a key role in the program and are invited by the directors of the two agencies to participate as appropriate in light of the agenda and annual work plan. The National Wildlife Federation, the National Audubon Society, the Sonora Desert Museum and, most recently, the Conservation Fund of Safari Club International have actively participated in the program. In addition, state fish and wildlife agencies from Texas, New Mexico, and Arizona have played prominent roles for some projects on border species. Bill Huey of New Mexico has been particularly active in joint projects. Without the cooperation of nongovernment organizations and the states there would be little actual program because frankly there is little or no money to work with. A key premise in all of the agreements within which the Fish and Wildlife Service works is that funding must generally come from elsewhere or be a combination of many different agencies and organizations.

The Fish and Wildlife Service has been engaged in bilateral activities with Nicaragua, Costa Rica, Panama, Ecuador, Argentina, Surinam, and Brazil within the Western Hemisphere in the past two years. All these contacts were by invitation of the respective governments. We cannot afford to go where we aren't invited nor can we do all that needs to be done in those countries where we are already working. Fortunately, we are not working alone. Many international organizations such as United Nations Environmental Program, International Union for the Conservation of Nature and Natural Resources, and United Nations Education, Scientific, and Cultural Organization and nongovernment organizations such as the Rare Animal Relief Effort, World Wildlife Fund, and Nature Conservancy have currently active programs. In Costa Rica the latter three organizations are joining with the U.S. Fish and Wildlife Service, the U.S. National Park Service, and the Agency for International Development to provide assistance to the Government of Costa Rica to set up a regional training facility for wildlife management. Costa Rica has itself offered to provide most of the costs and physical facilities while outside organizations will provide staffing and some operational funds.

These cooperative efforts are the backbone of the Fish and Wildlife Service's international work. Without outside help we cannot function in most countries. In a more general manner this illustrates the realities of today's world. North Americans cannot do everything for everyone nor should we. In most fields it would be unfounded arrogance to believe that we know enough to teach others how to manage their own resources. However, in this field of living resource management, we, along with the European tradition, have had a corner on the market. Theories of management practices and techniques and methods of conservation developed on this continent can still come as a revelation in many parts of the world. We have a valuable product to sell. Valuable to other countries now and to our own future generations if adopted by those countries. In areas where management theories are well understood, techniques, methods, and technical assistance are themselves the message.

The reason we cannot do as much as is needed is largely financial. We have urgent needs at home. Our own environment, while still basically sound, is deteriorating. Each dollar spent overseas is one dollar less we have to spend at home. Balanced against this is the fact that for every dollar spent overseas we can get ten dollars worth of benefits in that country. The investment overseas produces a high rate of return and is our investment in the future. Fortunately, the buying power of the U.S. dollar is still very high relative to benefits.

Let me give you an example of what I mean by investment in this area. Many managers of national parks, positions of authority in developing countries, received their training in the United States or Canada, particularly at the University of Michigan or they have attended United States and Canadian sponsored international seminar on park management. This seminar is supported by the United States and Canada. Scholarships to pay for attendance come from other countries, conservation organizations, and the various United Nations bodies. This investment has been critical to the rapid progress in developing a park system in third world countries. Within the last decade Costa Rica has gone from no parks to 14 with over 5 percent of the land area fully protected. The first parks director and the present director were both educated in the international parks seminar and the Michigan parks program.

To date we as wildlife managers have no comparable programs that have achieved such spectacular results. Perhaps it is time we initiate an international seminar in wildlife management to include water management, censusing methods, radio-tracking techniques, estimating yield, fire and forest management for wildlife and other topics basic to our own management science. Such a seminar could take advantage of our excellent state and provincial programs in the U.S. and Canada and different habitats north to south could be used to illustrate the practical application of management.

This idea is only one of many which shows how far low cost real progress might be made to address the coming crisis in wildlife conservation. The International Affairs Staff and those we work for, the U.S. Fish and Wildlife Service and the Department of the Interior, know the truth of Dave Munro's earlier remarks discussing future species losses. Eric Eckholm (1978) has recently published an essay discussing the same topic, indicating a potential loss of 20 to 30 percent of the earth's terrestrial fauna and flora by the year 2000. Massive efforts will cut this but the number of species inevitably being lost will still be enormous. Those of us who work in the international field and travel widely as a result can already see major changes during the last decade. Nepal and Thailand are nearly gone—logging is making inroads even into the national parks. Indonesia continues to cut forests far beyond their replacement rate and with accompanying major losses of soil. This same situation is occurring in many parts of Africa and some of South and Central America.

What we do now for conservation will be multiplied enormously in future years throughout the world. For this reason Assistant Secretary Herbst has also directed that the Fish and Wildlife Service take advantage of any conservation targets of opportunity that arise anywhere in the world.

The countries of India, Pakistan, and Egypt are particularly important because in these countries the U.S. has available excess foreign currencies accumulated during the years when the U.S. was exporting great quantities of food. The currencies are available to agencies for authorized purposes on request. In Pakistan we have recently negotiated over a half-million dollars worth of agreed conservation projects for a two-year period. In India the government is considering a similar dollar value in joint projects. For the past two years we have been implementing projects in Egypt and recent efforts have gone toward protection and transfer of Sinai parks and reserves with management and research intact. As you would guess this has been our most politically sensitive effort. The programs in these countries are particularly attractive because the cost in dollars is little or none. Airline tickets, per diems, and some other expenses can be paid in the excess currency.

As these programs develop, we will be soliciting assistance from government and the academic community for direct involvement. Cooperators must pay their own salaries but the Fish and Wildlife Service can cover most other costs.

The Indian program, is a good example of why we believe that, in spite of the gloom and doom, there may be some cause for optimism. Three years ago, millions in India were facing starvation each year; now India is a net exporter of food. Three years ago the population was growing far faster than resource development. Now, although the population is still growing at one million new people per month, there is more of a balance between population growth and development. In spite of these frightening figures, India has a pragmatic program for protecting its forests and wildlife from further immediate losses. A new national forest policy has been adopted and a national wildlife policy is almost completed. New parks are being gazetted and, for the first time, some Indian endangered species are being captive bred and reintroduced into the wild. Some of the new parks are a revelation to the Western mind. One Indian wildlife conservator in Andhra Pradesh in the dry central plateau has purchased abandoned land, forsaken even by the goats, to set up a new park. The rocky area was fenced and, through labor intensive management, trees and grasses were planted and nourished by hand. This barren rock, now after three years, has 15-foot (5 m) trees and is covered by waist-high grass. Blackbuck have been introduced and bred this year to double their numbers to over a dozen. Sixty species of birds are nesting where fewer than 10 were found previously. This area demonstrates the remarkable recuperative power of the land and the potential for growth when grazing is controlled. It really isn't so surprising since the flora has survived overgrazing for hundreds, if not thousands, of years. The Indians we deal with think nothing of planning for 30 to 50 years hence. The Fish and Wildlife Service projects in India, as well as other countries, are designed to buy time for these nations' natural environments, to allow the governments to find solutions to the population and economic problems without which there is no hope for wildlife.

The programs I've discussed today aren't by any means all the International Affairs Staff does. We have a large program with the Soviet Union, bilateral treaties with Japan, and a cooperative agreement with Spain. We provide the Executive Officer to the Survival Service Commission of the International Union for the Conservation of Nature and Natural Resources and are responsible for the initiation and negotiation of most new treaties for the Fish and Wildlife Service. This includes the Antarctic Living Resources Treaty, the German Migratory Species Treaty and a possible new treaty on migratory birds in the Western Hemisphere. Within the Fish and Wildlife Service, we do not handle the Convention on Trade in Endangered Species of Fauna and Flora, which is implemented by the U.S. Management and Scientific Authorities and we do not get involved in international permits or quotas for export and import of wildlife. We have quite enough to do already.

John Donne said "No man is an island." Likewise, we can say no country is an island free from the actions, aspirations, and advances of others. There is no "fortress America" in an ecological sense. This came home to me most clearly last week in Costa Rica. When I left the hotel one evening as the sessions ended I saw three hundred Baltimore Orioles roosting for the night in a tree outside the hotel, waiting to wing northward in the morning to their breeding grounds. What would they have done without the roosting tree or the nearby forest in which to feed?

What other countries do directly affects what we consider to be our resources. Perhaps if we had a broader perspective the Baltimore Oriole would be called the San Jose Oriole. A species which spends the hot Costa Rican summer temporarily sojourning elsewhere. Conservation beyond our borders is a challenge that goes beyond our feud between the state and Federal governments on who owns and manages wildlife. For us to be successful internationally we must all work together.

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The Great Lakes: Demands, Problems and Opportunities

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Shoreline Processes Affecting the Distribution of Wetland Habitat

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Introduction

Wetlands are common features of land-water interfaces throughout the Great Lakes-St. Lawrence River system. They are best developed where broad expanses of shallow water meet a protected shoreline with gradually increasing elevation. Shoreline contacts which provide protection from the full force of wind and wave action are required for extensive wetland development, since macrophytic vegetation and suitable soil or sediment features only persist under these conditions. Physical protection is lacking along bars, beaches, and abrupt shoreline interfaces, and the identity of these areas as wetlands must be inferred from other relationships.

Wetlands have been variously conceived during the past 20 years as a result of a broad range in interpretations provided by natural scientists and the increased interest in wetlands by the public. A perceptive discussion is provided by Cowardin et al. (1977) through the description of the continuum of environments where terrestrial and aquatic systems intergrade. To them, wetlands are lands where "the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or support the growth of hydrophytes." The deep water end of the continuum is marked by the growth limit of emergent macrophytes. It grades into "deep-water habitats," which are dominated by submerged aquatic macrophytes. The upland limit is exceeded when soils are no longer "hydric" in classification and the predominating vegetation is terrestrial rather than hydrophytic.

Along the eastern shoreline of Lake Ontario and the St. Lawrence River in New York State, we consider the wetland continuum to span a range of environments from the limit of submerged aquatic macrophytes at water depths of about 22 feet (7 meters)[1] to upland contacts which include sheer bedrock cliffs, drained lake plain sediments, and glacial drift soils of wide variety. Water levels fluctuate from 2–4 feet (0.6–1.3 m) annually, from peaks in June or July to minimums in December or January, and emergent wetlands systems are localized within the zone of seasonal drawdown. Deep-water emergent species are poorly represented, and the portion of the continuum corresponding to the vegetated littoral zone or "deep-water habitats" of Cowardin et al. (1977) intergrades with emergent systems which are usually above water for some portion of the year. Emergent wetland systems include a wide variety of physiognomically separable plant communities, dominated by herbaceous, shrub, and deciduous tree species (see Geis and Kee 1977 for details).

This paper reviews recent studies of the wetland continuum as expressed along the shoreline of eastern Lake Ontario and the St. Lawrence River. It summarizes data from studies of wetland distribution, species composition, primary production, and environmental control of wetland dynamics as they pertain to an understanding of shoreline processes affecting wetlands. It draws upon work completed by my students and our collaborators. The contributions of B. A. Gilman, J. Kee Alesandrini, N. P. Hyduke, D. J. Raynal, and E. W. Marshall to the overall effort have been significant and are gratefully acknowledged.

Wetland Distribution

An inventory of wetlands along the Jefferson County, New York, shoreline of Lake Ontario and the St. Lawrence River was conducted in 1974 and 1975 (Geis and Kee 1977). Larger wetland systems (about 25 acres, 10.2 ha, in size) lying within the zone of lake level influence were first identified using panchromatic black and white aerial photography. Low elevation, 70 mm color aerial transparencies were subsequently flown for each of these areas to permit cover mapping. A second inventory was made to locate and describe all coastal wetlands greater than one acre (0.4 ha) in size using panchromatic black and white aerial photography.

Forty-one major wetland units totaling 7,207 acres (2,947.7 ha) in size were located and described in detail. An additional 535 acres (218.8 ha) of emergent wetlands were located in 59 individual units of lesser size. The total shoreline wetland area, 7,742 acres (3,166.5 ha), includes shallow water submerged aquatic communities located within the limits of the wetland units as defined by land forms or the lakeward extent of emergent communities. No attempt was made to inventory the extent of the vegetated littoral zone which extends beyond the boundaries of the individual wetland units.

The occurrence, extent, and composition of wetlands systems was found to be dependent upon the morphology of the shoreline and its influence upon the hydrologic regime. Three broad categories of wetlands based on basin morphology were developed to characterize these relationships. Wetlands in all of these

[1]Unless stated, all water depths refer to mean low water datum, International Great Lakes Datum, 1955.

categories occupy protected stations, removed from the full force of wind and wave action.

Flood Ponds

Flood ponds occur in depressional areas physically separated from the lake by a barrier, usually a sand or cobble beach. Lake level influence is expressed through either underground seepage or connecting channels which may be temporarily, semipermanently,or permanently open. Water levels are usually augmented by inputs from tributary streams, and the hydrologic connection between lake and flood pond is more permanent where tributary flows are high. A pond or shallow, open water area is usually associated with these systems. Flood ponds are more common along the Lake Ontario shoreline where lowlands underlain by recent glacial and lacustrine deposits are situated immediately behind the present shoreline.

Bays

Wetlands also develop in bays which cut into the shoreline of the lake or river and are protected from open water by islands, shoals, or upland peninsulas. Although submerged aquatic vegetation is present in the shallow waters of bays throughout the area, extensive bay wetlands are more common along the St. Lawrence River than the eastern shoreline of Lake Ontario. Uplands associated with these systems are most frequently bedrock controlled, and the hydrologic connection with the lake or river is usually permanent.

Streamside Wetlands

Riparian wetlands extend inland along the floodplains and banks of tributary streams entering the lake or river. Their extent is a function of floodplain width, being greatest along larger streams with broad floodplains and least where stream banks are steep. Since most tributary streams enter the larger lake–river system through flood ponds and bays, the distinction between streamside wetlands and those of bays and flood ponds is imperfect.

The importance of protected shoreline positions to wetland distribution was demonstrated by an experiment conducted during the summer of 1974 in a flood pond (Black Pond) and a streamside (Campbell Marsh) wetland system along the Lake Ontario shoreline (Gilman 1976). Wave action was monitored 16 times using paired, chalked poles set in transects beginning at the lake and extending inland across each wetland. On Friday, poles were chalked to the water level and the following Monday the height of chalk washoff above the water level was recorded as an estimate of wave height.

Mean wave heights averaged over the duration of the experiment are given in Table 1. Wave heights decreased significantly ($P < .05$) from the lakeside position to measurement points within wetlands along both transects. A slight decreasing trend exists from deep to shallow water communities within each system, but this trend was not significant. Greater variation within transects occurred in the duration of measurable wave action. The reduction in wave action attributable to the physical effect of shoreline can be seen by comparing mean wave heights at the

Table 1. Mean wave heights and duration of wave action measured for sixteen, three-day intervals during 1974 in transects at two wetland systems along Lake Ontario. Data from Gilman (1976).

Location	Duration (weeks)	Mean wave height, inches
Black Pond		
Lakeside	16	12.9
Submerged aquatic	16	2.4
Floating aquatic	16	2.0
Old dead meadow	16	2.2
Recent dead meadow	13	1.8
Sedge grass	11	1.8
Sedge grass shrub	10	1.8
Shrub	0	0
Flooded trees	0	0
Campbell Marsh		
Lakeside	16	10.9
Stream middle	16	2.8
Streambank	16	2.6
Cattail	16	2.8
Sedge grass	11	2.4
Sedge grass shrub	8	2.6
Flooded trees	0	0

"lakeside" station with those of the "submerged aquatic" station at Black Pond and the "stream middle" station at Campbell Marsh.

Environmental Control of Community Composition

A wide variety of environmental variables have been shown to influence the dynamics and species composition of freshwater wetland systems (see Sculthorpe 1967, Van der Valk and Bliss 1971, Auclair et al. 1973, and Millar 1973). To examine these relationships we sampled net primary production of above ground plant parts at five intervals over the 1974 growing season. Permanent sample stations were located along the wetland continuum at Black Pond and Campbell Marsh. The relative contribution of each species to peak standing crop biomass was used as a measure of species importance. Water levels and physical and chemical characteristics of the substrate were determined concurrently. Data were analyzed by Bray-Curtis ordination (Bray and Curtis 1957) and simple linear correlation. Details of model construction are given in Gilman (1976).

A two-dimensional Bray-Curtis ordination of Campbell Marsh is given in Figure 1. Sample plots are located along axes derived from similarity comparisons using a coefficient of community matrix (Goodall 1973), and descriptive names are given to samples of like physiognomy. Four measures of water regime (mean, maximum, and minimum water levels and drawdown) were significantly correlated with stand position along both the x and y-axis. Additional significant correlations were demonstrated for substrate features (organic matter content and exchangeable bases in the shallow sediment layer for the x-axis; organic matter

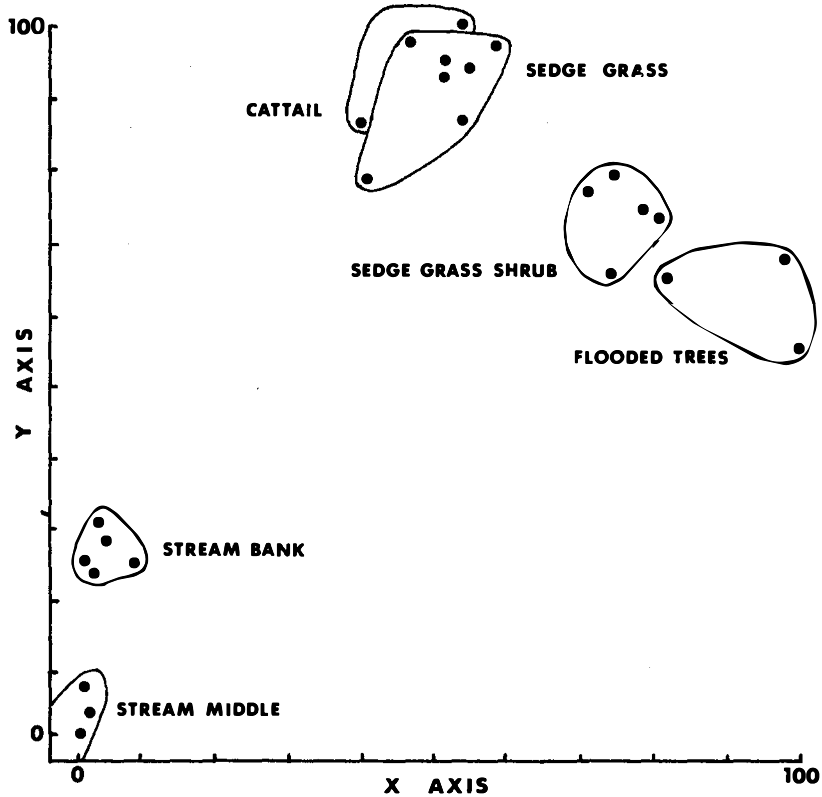

Figure 1. Two dimensional Bray-Curtis ordination of 25 plant community samples at Campbell Marsh (from Gilman 1976).

content, exchangeable bases and sediment textural variables of both shallow and deep sediment layers along the y-axis). A similar result was obtained for the Black Pond analysis, but the progression was less well ordered due to the severity of recent natural disturbance.

The correlation of substrate variables with ordination position describes a tendency for established wetland vegetation to alter its environment through the deposition of organic matter and the entrapment of sediments. However, we interpret this tendency to be depth related and dependent upon the primary influence of the hydrologic regime in patterning community composition.

The importance of the water regime in community development is emphasized by the successful construction of direct gradient diagrams based on mean water depth for both systems (Figures 2 and 3). Importance values of the major plant species are plotted over the position of each sample station along a linear gradient of mean annual water levels. Individual species importance curves were smoothed by calculating a moving average in 10 centimeter depth classes and replotting the adjusted value over the midpoint of that class. Details of model construction are given in Gilman (1976).

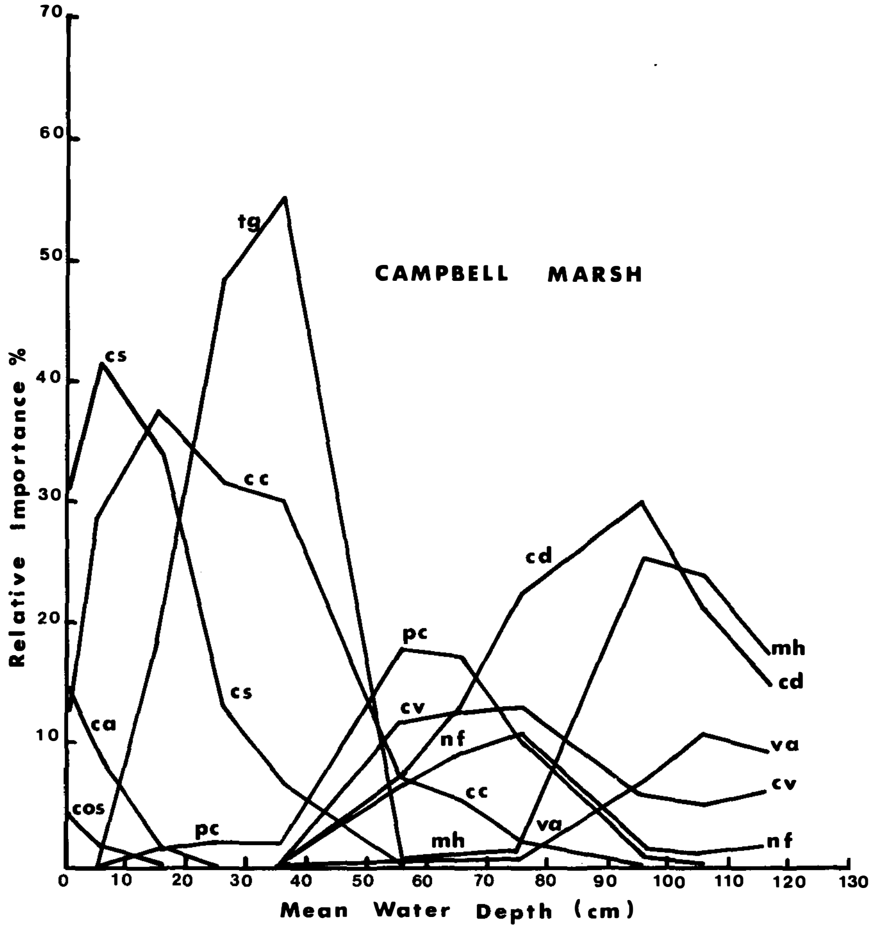

Figure 2. Distribution of wetland plant species along a water depth gradient at Campbell Marsh. Species indicated are *Myriophyllum heterophyllum* mh, *Ceratophyllum demersum* cd, *Vallisneria americana* va, *Chara vulgaris* cv, *Najas flexilis* nf, *Polygonum coccineum* pc, *Calamagrostis canadensis* cc, *Typha glauca* tg, *Carex stricta* cs, *Cornus amomum* ca, *Cornus stolonifera* cos (from Gilman 1976).

Gradually changing species composition with water depth is indicated in both systems. Weakly rooted submergents dominate the deeper end of the gradient, with emergent herbaceous and woody species increasing respectively in importance at shallower depths. Distinct nodes of compositional change, implying strong water level regulation, occur in Campbell Marsh (Figure 2) at depths of 10, 55, and 75 cms. The progression at Black Pond (Figure 3) is more gradual, and several species (notably *Ultricularia vulgaris*[2], *Lemna trisulca,* and *Cladophora glomerata* L.) nearly span the entire gradient.

[2]Vascular plant taxonomic nomenclature follows Fernald (1950).

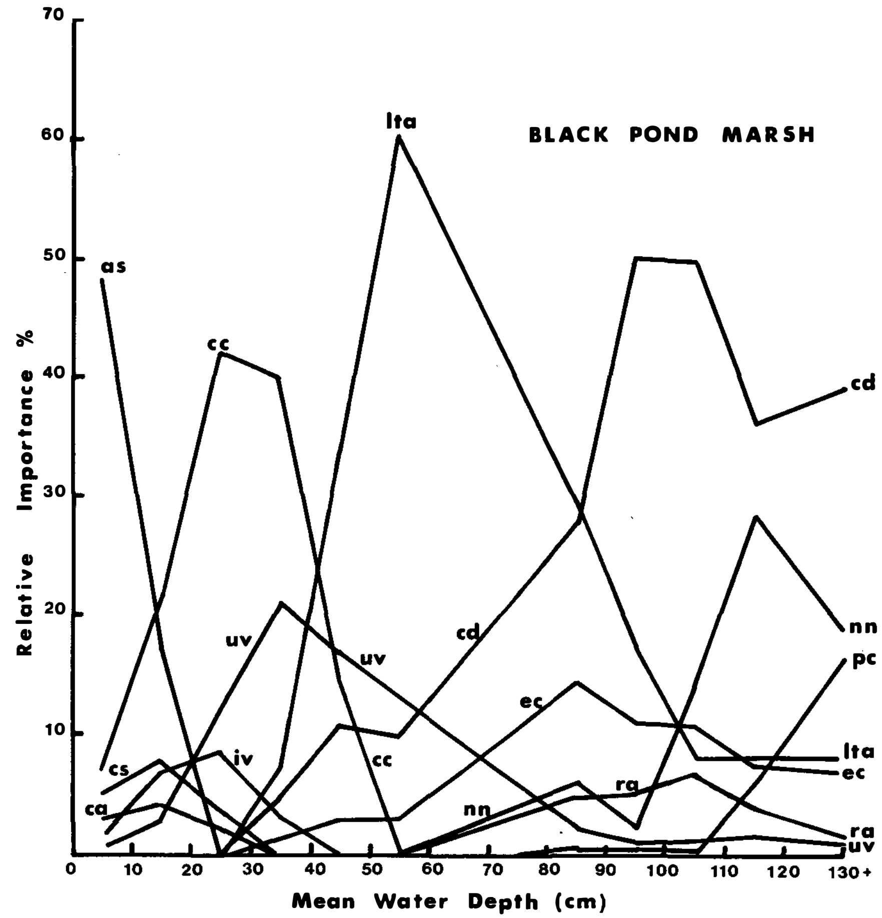

Figure 3. Distribution of wetland plant species along a water depth gradient at Black Pond. Species indicated are *Ceratophyllum demersum* cd, *Potamogeton crispus* pc, *Nuphar variegatum* and *Nymphaea tuberosa* nn, *Lemna trisulca* and *Cladophora glomerata* lta, *Ranunculus trichophyllus* ra, *Ultricularia vulgaris* uv, *Elodea canadensis* ec, *Ilex verticillata* iv, *Calamagrostis canadensis* cc, *Carex stricta* cs, *Cornus amomum* ca, *Acer saccharinum* as (from Gilman 1976).

Influence of High Water on Wetland Communities

An episode of higher than normal water levels occurred in Lake Ontario during 1972, 1973, and 1974 (Palm 1975). Since this event occurred at the same time as our studies, we were able to observe some of the consequences in shoreline wetlands. Widespread areas of dead wetland vegetation were apparent during the 1974 growing season. While vegetative die-off was visible in all physiognomic types, it was most extensive at the leading edges of cattail and sedge-grass dominated emergent communities. The aerial appearance of a die-off zone in a cattail community at Long Carry Marsh is shown in Figure 4, while a surface-level photograph of this same system is included as Figure 5.

The extent of dead vegetation in the 41 major wetland systems along the Jefferson County shoreline of Lake Ontario and the St. Lawrence was determined during our 1974 inventory (Geis and Kee 1977). Concurrent measurements of water levels and field reconnaissance during the period confirmed that the timing of die-off corresponded with the 1972–1974 high water episode. A total of 769 acres (314.5 ha) of dead vegetation were inventoried in three broad cover categories (dead emergents, dead trees, and dead shrubs). Most of the die-off (78.6 percent of the total dead area) occurred in the emergent cover types. A total of 10.7 percent of the total wetland area contained dead vegetation. The fraction is slightly higher (16.1 percent) when the area of dead emergents is equated to the total area of emergent vegetation in the 41 wetland segments. Also, the impact was highest in flood ponds, with proportionately less dead vegetation present in wetlands along bays and tributary streams.

In areas where the influence of high water was less prolonged, reduced dry matter production occurred rather than complete vegetative death. Gilman (1976) found that the net primary production of narrow-leaved meadow emergent communities averaged 735.8 g/m^2 (grams per square meter) in healthy streamside systems, 567.3 g/m^2 in a partially impacted flood pond community of similar composition, and 100.7 g/m^2 in dead emergent areas in the same flood pond system. These data are for above ground plant parts and are not adjusted for ash content. The dead community contained the previous year's detritus, but little current growth of component grasses or sedges. The current year's production

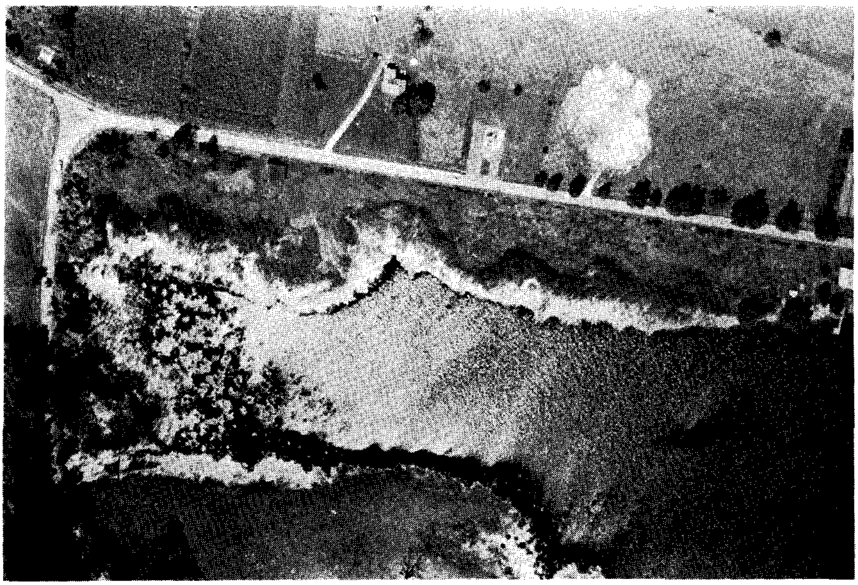

Figure 4. Aerial view of Long Carry Marsh, Jefferson County, New York, on August 7, 1974. The light gray zone along the top shoreline is dead cattail. Living cattails are visible as a dark gray zone immediately inland.

Figure 5. Surface view of dead cattail area at Long Carry Marsh illustrated in Figure 4. Note the tall, living cattails, immediately behind the impacted zone in the upper right corner of the photograph.

was made up of species from adjacent submerged aquatic communities, rather than partially impacted communities of meadow emergents.

A complete assessment of the impact of high water levels on wetland vegetation is far from simple. The short term response is swift, and reduced primary production or vegetative death are the immediate consequences. However, productivity appears to recover with equal rapidity if the high water episode is temporary. Visual inspection during 1975 and 1976 suggested that the standing crop biomass of previously dead areas approached that of non-impacted areas by the 1976 growing season. However, community composition was markedly different, with *Sparganium eurycarpum* forming dense, monospecific stands in areas of prior dieback.

The precise sequence of events precipitating wetland die-off is also difficult to establish. McDonald (1955) described two periods of extensive die-off of emergent wetland species at Point Mouillée, Michigan on Lake Erie which corresponded with episodes of abnormally high winter lake levels. The character of the die-off, its distribution within wetland systems, and the dynamics of system change following the vegetative death are strikingly similar to our observations along Lake Ontario. Winter water levels sufficiently high enough to flood portions of the emergent zone occurred from late January through March, 1973 and from middle February to middle March, 1974.[3] The probability that winter water levels were the causative factor is further supported by the high tolerance of these species to

[3]Data from NOAA Lake Survey Center, Detroit, Michigan—Oswego, New York, gauging station.

submergence during the growing season, their sensitivity to anaerobic conditions during winter (Laing 1941), and the recent evidence of Bernard and Gorham (1978) of significant winter shoot growth in wetland sedges.

Winter Characteristics of Wetlands

In winter, wetlands sit at the interface between partially frozen shorelands with a deep snow cover and seasonal icelands with an established ice cover and shallower snow depths (Marshall 1978). Ice and snow characteristics of shoreline wetlands are illustrated in Figure 6. Data were collected by direct measurement of ice and snow features at Tibbits Creek Marsh, a small riparian wetland system along a stream which enters the St. Lawrence River near Ogdensburg, New York. Measurements were made on February 15, 1979, and are representative of midwinter conditions. Additional descriptive information is drawn from a survey of St. Lawrence River ice conditions by Marshall (1978).

Deep snow covers accumulate in wetlands from direct snowfall and the redeposition of windblown snows off of adjacent bays and channels. Snowdepths are variable, with drifts associated with clumps of dead standing vegetation separated by hollows where the vegetation has become flattened (compare profiles 1 and 2 in Figure 6). Ice below the snow pack is irregular in distribution and variable in thickness. Where present it may be frozen to the bottom, floating, or suspended due to water level fluctuations. The deep snow pack insulates the wetland surface and prevents ice formation, especially in areas where a loose layer of dead vegeta-

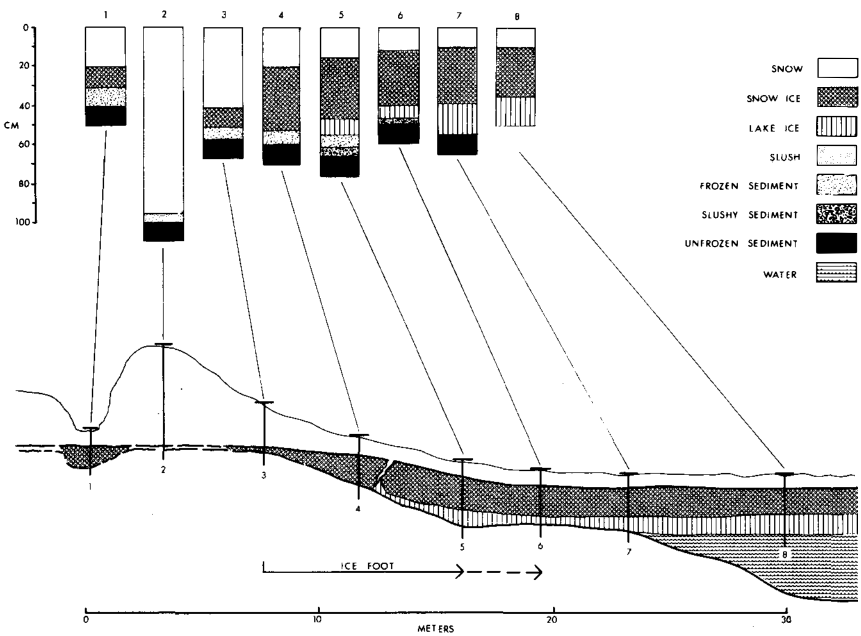

Figure 6. Ice and snow characteristics of Tibbits Creek Marsh, St. Lawrence County, New York on February 15, 1979.

tion remains. This conditions may change in the spring when thawing and refreezing create a snow ice cover of short duration.

The wetland snow pack is low in density, and much of it consists of recrystallized snows resulting from the migration upward of water vapor from lower, warmer snows resting on unfrozen wetland substrates. The redistribution of water vapor to upper, colder portions of the snow pack results in the formation of voids of irregular size and shape near the wetland surface. Voids are prevented from collapse by vegetative clumps and the formation of ice crusts on their inner surfaces. Chimney-like voids extend through the snow pack around clumps of dead vegetation. They channel warm water vapor from the unfrozen surface through the snow pack and out the chimneys. Voids and chimneys form an interconnected matrix of protected habitats beneath the snow pack.

The linkage of wetlands to the ice cover of adjacent shallow water areas occurs through the development of a feature called the ice foot (Marshall 1978). The ice foot is a zone of grounded ice which incorporates frozen sediments and extends into the wetland edge to a variable extent. It forms by direct freezing of substrates lying above the prevailing water level at the time of first ice formation (profiles 3 and 4 in Figure 6) or by the deposition of slush, sludge, and new ice at the wetland edge prior to the formation of a stable ice cover (profiles 5 and 6). As the ice cover builds and thickens, the depth of freeze down increases and the ice foot migrates outward.

A substantial degree of natural habitat disruption occurs during spring breakup in the ice foot zone. Along the St. Lawrence River, water levels in bays and wetlands begin to increase well in advance of the timing of stage increases as measured at channel gauging stations (Geis and Hyduke 1978), and the early phases of spring breakup occur during a period of rising water levels. Bottom lifting prior to melting results in a zone of lifting and turnover of sediments at the wetland edge. Roots, rhizomes, and overwintering structures are dislodged and exposed to freezing. In addition large sections of the wetland edge can be broken off due to the continuity of bay ice and frozen sediments. Wetland islands of varying size are created annually by this process.

Our studies during the winter of 1978 suggest extreme sensitivities of winter wetland features to water level fluctuations. The formation of unique ice and snow features of these areas is dependent upon the maintenance of winter water levels below the elevation of the wetland edge, creating moist rather than flooded conditions. Marshall (1978) suggests that abnormally high water levels would modify wetland snow and ice conditions, creating slush then snow ice layers at the sediment surface. The freeze down zone would also increase through greater ice foot migration inward. Abnormally lower water levels would result in ice cover collapse and ice foot migration outward. Both conditions would increase the degree of natural habitat disruption that occurs during spring breakup, through increased edge break off and bottom lifting.

Implications

Implications for Wetland Management

Several lines of evidence suggest that water levels represent the single most important variable in defining the extent, species composition, and stability of coastal wetlands along Lake Ontario and the St. Lawrence River. This conclusion has been frequently stated in other contexts (see Gosselink and Turner 1978, Weller 1978 for excellent reviews). Our data suggest that coastal wetlands are intricately tuned to the water regime during both the growing and dormant season. Modifications in water regime, induced by either natural process or through regulation, can result in changes in primary production and competitive dynamics; distributional shifts in wetland communities through the die-off of components of the wetland continuum and temporary niche filling by other species; modification of winter snow and ice covers with implications for both plant and animal components of wetland systems; and the expansion of natural tendencies for habitat disruption due to the extreme sensitivity of the contact zone between wetlands and shallow waters during winter. Finally, it must be noted that our current understanding of wetland–water relationships is not consistent with widespread and finely turned application of this important management tool.

Theoretical Implications

The ecological literature lacks a modern treatment of successional relationships in wetland systems. In addition, a general appreciation of wetland dynamics has not been furthered by the frequent textbook introduction which represents wetlands as the last infilling stages of ponds and lakes. While a Clementsian hydrosere, composed of well-ordered zones of wetland communities advancing outward through substrate building and amelioration, has not been shown to provide a useful general model (e.g. Mandossian and McIntosh 1960, Auclair et al. 1973), a comprehensive alternative has not been offered.

Our studies in wetlands along the Lake Ontario and St. Lawrence River shorelines suggest that the following relationships bear upon the question.

1. The wetland continuum responds to long and complex environmental gradients dominated by the water regime and expressed over relatively short surface distances.
2. While autogenic accumulation and modification of substrate occurs, these tendencies may be offset by a continuous, external or allogenic environmental dimension including wind and wave action and ice-propagated disruptions.
3. Pulses of environmental conditions, often involving the hydrologic regime, behave like disturbances. They may temper the state of the prevailing environmental complex to offset autogenic progression and increase compositional complexity.
4. The existence of non-succeeding wetland edges maintained by allogenic influences does not diminish the significance of autogenic process in internal system dynamics. Rather, it requires that succession be viewed as a tendency opposed in wetland systems by a variable environmental complex which often dominates and mitigates its inferred directions.

Summary

Wetlands along the eastern shoreline of Lake Ontario and the St. Lawrence River in New York State are separated from the high-energy shoreline interface in flood ponds, bays, and the floodplains of tributary streams. Hydrologic variables

(mean, maximum, and minimum water depths and seasonal drawdown) are the most important variables affecting wetland community composition. While physical and chemical characteristics of the substrate are also correlated with community composition, they do not appear to operate independently of the hydrologic regime.

Water level changes coincident with the 1973 and 1974 water years resulted in widespread dieback in shoreline wetland habitats. The area of this impact was measured through the use of low elevation aerial photography. A total of 769 acres of wetland vegetation were affected along the shoreline of Jefferson County, New York. This figure represents 10.7 percent of the total area of all wetland units along that shoreline. Most of the dieback (78.6 percent) occurred in emergent wetland types. Recovery has been variable. While primary production recovered rapidly, species composition has yet to return to its original state.

Winter characteristics of shoreline wetlands include unique ice and snow features of importance to ecosystem stability. The contact zone between snow covered wetlands with unfrozen substrates and adjacent shallow water areas with stable ice covers creates sensitivities which can modify wetland composition and distribution. Annual disruptions within this contact zone include freeze down and the incorporation of sediments into the ice layer, bottom uplifting and turnover in the freeze down zone, and breakage of the wetland edge during spring breakup. The expression of each of these characteristics is dependent upon the status of winter water regimes.

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Organochlorine Contaminants and Trends in Reproduction in Great Lakes Herring Gulls, 1974–1978

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Introduction

In 1973, under its responsibilities to the Great Lakes Water Quality Agreement between the United States and Canada, the Canadian Wildlife Service (CWS) began a program to monitor contaminants in wildlife in the Great Lakes Basin. This became part of a larger Surveillance Program for the Great Lakes Water Quality Board of the International Joint Commission (IJC) to monitor trends in eutrophication and contamination of persistent and/or toxic substances in the international boundary waters of the Great Lakes.

Species at the top of various food webs have often been considered as indicators of overall environmental contamination because they bioaccumulate pollutants to high levels and reflect contaminant levels at lower trophic levels (Moore 1966). In choosing an indicator species for Great Britain, Moore (1966) concluded that molluscs as well as herbivorous and insectivorous fish, mammals and birds were not suitable as indicator species, since their residue levels were generally too low. Raptors which bioaccumulate high levels of persistent contaminants, on the other hand, have lower acute toxicity thresholds and are therefore not available as indicator species. He concluded that two groups of birds: carrion eaters (Corvidae), and fish-eating waterbirds, best satisfied the requirements as indicators of persistent toxic contaminants.

Also, aquatic systems (as compared to terrestrial ones) ultimately reflect persistent pollutants coming from the atmosphere and become a natural sink for urban and agricultural runoff, as well as for direct pollution from urban and industrial effluents.

The herring gull (*Larus argentatus*) was selected as the best available indicator species for our program (Peakall et al. 1978, Gilman et al. 1977a, Gilman et al. 1977b, Norstrom et al. 1978). Its useful characteristics are that: (1) within the Great Lakes Basin, adults are essentially resident (nonmigratory), although there is some inter-lake movement in winter (this means that the birds are not exposed to pollutants outside the Great Lakes Basin after they are one year of age); (2) it is primarily piscivorous but feeds on a wide range of food and is thus an integrator of overall pollution in the Basin; (3) it nests on the ground in large colonies, its entire breeding population can be easily censused, and it is found on all of the Great Lakes; (4) it is widely distributed throughout the northern hemisphere and information is potentially available for international purposes; and (5) it has proven to bioaccumulate extremely high levels of organochlorine pollutants of industrial and agricultural origin.

Eggs were chosen as the monitor tissue since they are readily accessible and impact of collection to the monitored population is minimal. Also, the lipid content of herring gull eggs is relatively high (7–11 percent). Residue levels in eggs have been found to reflect total body PCB and DDE levels in herring gulls (Anderson and Hickey 1976), total body DDE in European sparrowhawks (*Accipiter nisus*) (Bogan and Newton 1977), dieldrin levels in prairie falcon adipose tissue (*Falco mexicanus*) (Enderson and Berger 1970), and DDE, mirex, HCB and dieldrin levels in herring gull liver tissue (unpublished data). Egg levels are therefore taken to be a reflection of levels in the adult population.

In this paper we describe trends of the major organochlorine residues found in Great Lakes herring gulls since 1974. We intend to show problem areas of contamination, the relationship of contaminants to reproductive success of the herring gulls in the Great Lakes Basin, and to forecast, if possible, the future contamination levels and the effects of remedial action in the Great Lakes ecosystem.

Materials and Methods

Egg Collection

In 1974, two Herring Gull Monitor Colonies were designated in each of the four Great Lakes which border Canada (Figure 1). Geographical separation and ease of access were the two main criteria for selecting the colonies. In 1974, 1975 and 1977 ten Herring Gull eggs were collected from each gull colony. One egg was randomly selected from each of ten clutches distributed throughout the colony. The stage of incubation varied in the eggs but was generally early. In 1978, only fresh eggs were collected.

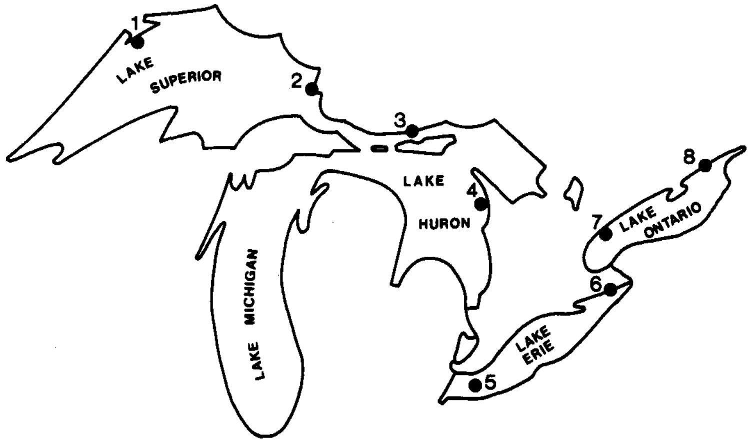
All colonies were visited by boat. Eggs were placed in cartons for transportation and were stored at 5° C within two days. Each egg was weighed and measured (length and width). It was then cut open around the middle and the contents put into a hexane rinsed glass jar with an aluminum foil lined lid and frozen.

Reproductive Assessment

"Fledging" success, unless otherwise specified, is based on the number of chicks per nest surviving to 21 days of age. Twenty-one days is an arbitrary and commonly used age, after which post-hatch mortality is minimal and locating the chicks becomes increasingly difficult (Harris 1964, Dexheimer and Southern 1974, Haycock and Threlfall 1975, Gilman et al. 1977a, and Ryder and Carroll 1978).

Two types of reproductive assessment were used in this study. The first, used from 1974 to 1977, consisted of visiting the colony every 1–4 days and keeping track of individual chicks until they were 21 days old. Nests were often fenced to aid in locating the chicks. In 1975, in an effort to obtain a complete coverage of the lakes, one monitor colony per lake was assessed using this method (Gilman et al. 1977a). Assessments in 1974 and 1976 were more sporadic and focused on Lake Ontario since reproduction there was known to be low (Gilbertson 1974, Gilbertson and Hale 1974, Teeple 1977).

In 1978, a method was sought by which more colonies could be assessed and the disturbance associated with frequent visitation reduced. A method was adopted based on three visits to each colony which is similar to that used by Kadlec and



1 GRANITE ISLAND*
2 MAMAINSE
3 DOUBLE ISLAND
4 CHANTRY ISLAND
5 MIDDLE ISLAND
6 PORT COLBOURNE LIGHTHOUSE BREAKWATER
7 MUGGS ISLAND**
8 SNAKE ISLAND†

* SILVER ISLET WAS USED IN PLACE OF GRANITE ISLAND IN 1975 AND 1977; THE COLONIES ARE AT OPPOSITE ENDS OF BLACK BAY.

** IN 1978, HALF OF THE EGGS WERE TAKEN FROM NEARBY LESLIE SPLIT.

† NEARBY WEST BROTHERS ISLAND WAS USED IN 1974 AND 1975.

Figure 1. Annual herring gull monitor colonies in the Great Lakes.

Drury (1968). The first visit is made late in incubation when the maximum number of nests can be expected. The purpose of this visit is to determine the number of active nests on either the entire colony if feasible or on a representative subsection which is then separated (when possible) from the rest of the colony by a chicken wire fence 1 meter high. The second visit is made when the young herring gulls are at an average calculated age of 21 days. On this visit each chick caught is sprayed on the back with a small amount of paint. The third visit is made on the following day when again all chicks are recorded and marked with a second color. Chicks which had been marked the day before are tallied separately from previously unmarked ones and a mark-recapture index, assuming random mixing, is used to calculate the total number of herring gull chicks on the island (or enclosure). From these data and the number of active nests established from the first visit, the number of young produced per pair is calculated. The purpose of this assessment is to identify colonies where herring gulls are reproducing poorly (less than 0.5 young per pair) and not to distinguish fine differences between normally reproducing colonies (greater than 0.8 young per pair).

Chemical Analysis

Whole egg homogenates were analysed at the Ontario Research Foundation, Mississauga, Ontario, by gas chromatography for PCBs and organochlorine pesticides (Reynolds and Cooper 1975) and were analysed after nitration for mirex related compounds (Norstrom et al. 1979). Selected duplicate samples from each year were analysed by gas chromatography for organochlorine compounds by the CWS. Confirmations were performed on Lake Ontario samples (Hallett et al. 1976) and Lake Erie samples (unpublished). This paper will restrict itself to the major organochlorine contaminants, DDE, DDT, HCB, dieldrin, mirex and PCBs. PCBs were measured against a standard of Aroclor 1254 and 1260 mixed in equal proportion, which is considered to best match the residue found in Great Lakes herring gulls.

Statistical Analysis

Selected sample sets were tested for normality by graphical methods since samples of 10 are too small for the calculations of moments. Given that most parametric statistics are not affected by slight deviations from normality, they were used throughout. By restricting the contaminants to the six previously mentioned, we were able to work well over detection limits and thus eliminate most of the skewness commonly found in residue data. Paired t-statistics were used to test differences between years within colonies. These were modified to account for heteroscedastic samples whenever necessary. Finally, 1974–1978 trends were fitted to linear and log-normal regressions. Within year samples from different colonies were compared by the Student-Newman-Keuls multiple comparison test (Sokal and Rohlf 1969).

Results

Chemical Residues

The results of the organochlorine analysis in Great Lakes herring gull eggs are presented in Table 1. PCBs were the highest residues found in eggs from all lakes ranging from 42–180 ppm. They are followed by DDE (3–24 ppm) and mirex (0.02–7.4 ppm). Dieldrin, HCB and DDT all range between 0.05 and 1.2 ppm.

Pair-wise Comparisons Between Years

The results of paired comparisons are summarized by compound without respect to location in Table 2a and by colony without respect to compound in Table 2b. Fifty-two percent (149/288) of all comparisons showed statistically significant ($P < .05$) declines, 2 percent (7/288) showed significant increases and 46 percent (132/288) showed no change in residue levels over the period 1974 to 1978.

On a compound basis (Table 2a), between 50 percent and 61 percent of the comparisons showed significant declines except for dieldrin where only 29 percent showed declines. However, significant increases were present in up to 4 percent of the comparisons. DDE and DDT showed the greatest number of increases (2) while dieldrin, HCB and PCBs had one each. Since the beginning of the study, mirex has never increased.

In terms of actual concentration, the largest decrease (1974 to 1978) for individual contaminants was: DDE: from 21 to 6 ppm, and HCB from 0.47 to 0.14 ppm

Table 1. Mean levels (± standard deviation) of six major organochlorine contaminants at eight monitor colonies on the Great Lakes in 1974, 1975, 1977 and 1978. The extremities of the vertical lines point to significantly different ($P < .05$) contaminant levels.

LAKE ONTARIO		% FAT	DDE	DDT	DIELDRIN	HCB	MIREX	PCBs
SNAKE								
	1974	7.2 ± 1.4	21 ± 9.1	1.0 ± 1.1	0.47 ± .25	0.56 ± .39	6.6 ± 2.8	14 x 10^1 ± 49
	1975	7.8 ± 1.7	24 ± 6.1	0.23 ± .17	0.35 ± .20	0.22 ± .20	6.0 ± 2.3	18 x 10^1 ± 51
	1977	9.6 ± 1.5	17 ± 4.7	0.11 ± .06	0.50 ± .10	0.50 ± .11	2.9 ± 1.1	12 x 10^1 ± 33
	1978	9.7 ± 1.6	10 ± 2.9	0.07 ± .02	0.28 ± .10	0.35 ± .12	1.7 ± 0.51	71 ± 20
MUGG'S								
	* 1974	7.8 ± 1.2	23 ± 5.5	1.2 ± .79	0.46 ± .13	0.60 ± .36	7.4 ± 4.7	17 x 10^1 ± 48
	1975	7.7 ± 0.8	22 ± 5.5	0.13 ± .06	0.24 ± .16	0.45 ± .26	3.4 ± 1.4	11 x 10^1 ± 21
	1977	8.8 ± 1.0	13 ± 2.5	0.12 ± .05	0.27 ± .08	0.34 ± .06	2.1 ± 0.4	87 ± 19
	+ 1978	8.6 ± 1.0	11 ± 3.0	0.10 ± .05	0.25 ± .05	0.28 ± .06	1.4 ± 0.7	75 ± 17
LAKE ERIE								
PT. COLBOURNE								
	1974	8.5 ± 1.0	8.7 ± 3.3	0.23 ± .07	0.37 ± .13	0.21 ± .05	0.84 ± .51	73 ± 20
	1975	8.3 ± 0.6	7.9 ± 1.8	0.10 ± .06	0.38 ± .14	0.17 ± .05	0.42 ± .17	53 ± 14
	1977	9.8 ± 1.6	7.6 ± 1.7	0.06 ± .03	0.50 ± .26	0.19 ± .03	0.51 ± .20	59 ± 13
	1978	9.0 ± 1.0	5.6 ± 1.3	0.09 ± .06	0.28 ± .09	0.09 ± .02	0.38 ± .16	46 ± 11
MIDDLE								
	1974	8.5 ± 0.9	5.6 ± 1.6	0.32 ± .17	0.34 ± .14	0.38 ± .12	0.44 ± .43	72 ± 14
	1975	8.4 ± 0.8	6.9 ± 1.7	0.10 ± .07	0.28 ± .17	0.23 ± .09	0.22 ± .06	71 ± 13
	1977	9.0 ± 1.1	7.4 ± 2.2	0.05 ± .03	0.31 ± .09	0.19 ± .06	0.39 ± .34	78 ± 24
	1978	8.8 ± 1.1	3.0 ± 1.0	0.05 ± .03	0.21 ± .06	0.09 ± .03	0.02 ± .05	42 ± 11

N.B. N EQUALS 10 EXCEPT FOR * (9) AND + (8)

Table 1. Continued.

LAKE HURON	% FAT	DDE	DDT	DIELDRIN	HCB	MIREX	PCBs
CHANTRY							
1974	8.2 ± 1.1	21 ± 8.6	0.63 ± .23	0.47 ± .18	0.47 ± .23	2.2 ± 2.1	86 ± 22
1975	8.6 ± 0.8	12 ± 4.4	0.04 ± .03	0.31 ± .20	0.17 ± .05	0.48 ± .56	39 ± 17
1977	9.4 ± 0.8	13 ± 4.6	0.09 ± .05	0.57 ± .25	0.17 ± .08	0.34 ± .22	64 ± 16
1978	11 ± 1.3	6.0 ± 2.5	0.05 ± .03	0.22 ± .09	0.14 ± .07	0.26 ± .33	32 ± 12
DOUBLE							
1974	9.3 ± 0.9	14 ± 6.7	0.55 ± .28	0.53 ± .16	0.30 ± .08	0.52 ± .22	56 ± 17
1975	7.3 ± 1.1	16 ± 8.5	0.17 ± .10	0.41 ± .18	0.24 ± .08	0.55 ± .67	46 ± 15
1977	9.4 ± 2.9	19 ± 15	0.09 ± .07	0.51 ± .24	0.21 ± .05	0.55 ± .57	77 ± 48
1978	9.0 ± 0.6	7.0 ± 2.6	0.09 ± .02	0.22 ± .12	0.09 ± .05	0.16 ± .22	33 ± 9.5
LAKE SUPERIOR							
MAMAINSE							
1974	8.7 ± 1.0	14 ± 4.1	0.82 ± .47	0.42 ± .15	0.30 ± .14	0.76 ± .66	50 ± 10
1975	7.2 ± 1.4	22 ± 8.6	0.72 ± .67	0.32 ± .11	0.26 ± .08	1.3 ± 1.7	70 ± 37
1977	9.3 ± 0.9	12 ± 4.3	0.07 ± .06	0.40 ± .17	0.13 ± .06	0.42 ± .79	56 ± 20
* 1978	9.3 ± 0.8	9.7 ± 4.8	0.10 ± .10	0.40 ± .43	0.09 ± .05	0.15 ± .16	37 ± 16
GRANITE							
* 1974	8.8 ± 0.9	19 ± 7.0	0.83 ± .44	0.61 ± .17	0.22 ± .12	1.3 ± .73	75 ± 18
1975	8.2 ± 0.9	24 ± 11	0.25 ± .12	0.44 ± .34	0.21 ± .12	0.62 ± .37	82 ± 33
1977	9.2 ± 0.8	11 ± 6.9	0.06 ± .03	0.35 ± .16	0.12 ± .07	0.24 ± .23	55 ± 22
1978	9.7 ± 0.4	9.6 ± 3.3	0.12 ± .05	0.39 ± .17	0.14 ± .06	0.39 ± .48	45 ± 11

N.B. N EQUALS 10 EXCEPT FOR * (9)

Table 2. Results of *t*-tests of between-year changes in levels of six contaminants for all eight colonies. Entries represent the number of tests which showed significant ($P < .05$) increases (↑), decreases (↓) or no difference (↔) between any two years. The information is presented by (a) contaminant, (b) colony and (c) lake.

(a)

Compound:	DDE	DDT	Dieldrin	HCB	Mirex	PCBs	Total	Percent
Direction of change	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔
Total	28 2 18	29 2 17	14 1 33	24 1 23	25 0 23	29 1 18	149 7 132	51 2 47
Percent	58 4 38	61 4 35	29 2 69	50 2 48	52 0 48	60 2 48	52 2 46	

(b)

Lake:	Ontario		Erie		Huron		Superior		Total	Percent
Colony:	Snake	Mugg's	Colborne	Double	Chantry	Double	Mamainse	Granite		
Direction of change	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔	↓ ↑ ↔
Total	19 1 16	23 0 13	15 0 21	19 1 16	20 3 13	19 0 17	14 1 21	20 1 15	149 7 137	51 2 47
Percent	53 3 44	64 0 36	42 0 58	53 3 44	56 8 36	53 0 47	39 3 58	56 3 42	51 2 47	

(c)

	Ontario			Erie			Huron			Superior		
Direction of change	↓	↑	↔	↓	↑	↔	↓	↑	↔	↓	↑	↔
Total	42	1	29	34	1	37	39	3	30	33	2	37
Percent	57	2	40	47	2	51	54	4	42	46	3	52

(Chantry Island, Lake Huron); DDT: from 1.2 to 0.1 ppm; mirex: from 7.4 to 1.4 ppm and PCBs: from 170 to 75 ppm (Mugg's Island, Lake Ontario); and dieldrin: from 0.53 to 0.22 ppm (Double Island, Lake Huron).

On a colony basis (Table 2b), Mamainse Harbour in Lake Superior and Port Colborne in Lake Erie showed the least improvement or the fewest number of declines (14/36 or 39 percent and 15/36 or 42 percent, respectively). At all other colonies, between 53 percent and 64 percent of all paired comparisons were declines with Mugg's Island showing the most. Pooling the individual colonies by lake, (Table 2c) Lake Ontario showed the highest proportion of declines (58 percent), followed by Lakes Huron (54 percent), Erie (47 percent) and Superior (46 percent).

On a lake basis, comparisons between 1977 and 1978 show that the best overall recent improvement comes from Lake Erie (9/12 decreases), followed by Lake Huron (7/12), Lake Ontario (6/12) and Lake Superior (1/12). Lake Superior showed the only increase (DDT on Granite Island), but generally remained stable.

Trend Analysis

All residue data for the four years monitored were fitted to linear and log-linear regressions (Table 3). All of the resulting trends were negative. A log-linear model fit indicates a constant rate of change. Mirex on Mugg's Island (Lake Ontario) is given as an example (Figure 2). The slopes of the residue trends, which were best approximated by the log-linear model were used to obtain a half-life value for residues in the Great Lakes system. For both linear and log-linear models, the

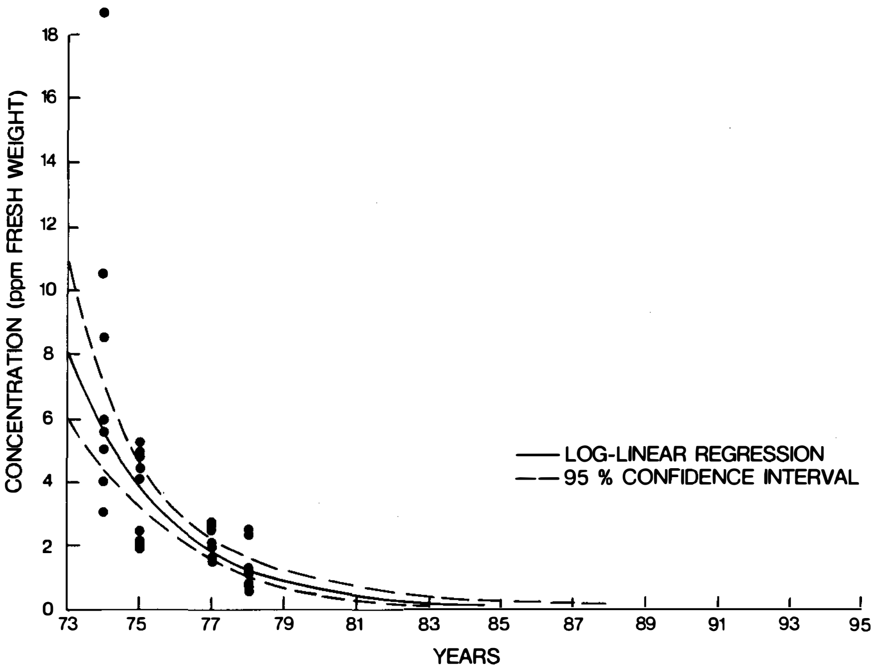


Figure 2. Mirex, Mugg's Island, Lake Ontario log-linear regression, 1974–1978.

Table 3. Significant ($P < .05$) linear and log-linear trends and derived predictions for the 1974–1978 residue data.

Lake	Colony	Chemical	Significant regression		Linear model			Log-linear model		
			linear	log linear	Yearly decrease (ppm)	Projected year of non-detection[c]	95% confidence interval	Half life (years)	Projected year of non-detection	95% confidence interval
Ontario										
	Snake	Mirex	[b]	[a]	1.3	1980	(1979–81)	2.1	1994	(1991–2001)
	Mugg's	DDE	[b]	[a]	3.4	1982	(1980–83)	3.3	2012	(2005–24)
		HCB	[a]		.07	1982	(1980–92)			
		Mirex	[b]	[a]	1.3	1979	(1978–81)	1.9	1992	(1989–97)
Superior										
	Granite	PCB		[a]				4.8	2037	(2017–80)
	Mamainse	HCB	[a]	[b]	.05	1980	(1979–83)	2.4	1986	(1984–90)

[a] best fit
[b] good fit ($P < .05$)
[c] N.D. .01 ppm

slope was used to estimate a year when the residue will become <0.01 ppm (the level we presently use as our detection limit).

The projected year when residues reach 0.01 ppm as extrapolated from the linear model, is considered to reflect the most rapid decline possible. Estimations from the log-normal model may be considered a more conservative prediction for disappearance of residue loadings in herring gull eggs and ultimately from the Great Lakes ecosystem. These predictions will hold providing there is no drastic change in the aquatic food supply of the herring gulls or the availability of the organochlorine residues to that food supply.

Chemical Residues–Within Years

With two exceptions, Snake and/or Mugg's Islands in Lake Ontario were the two highest ranking colonies for residues of DDT, DDE, HCB, mirex and PCBs. Colonies from the upper lakes were consistently high for dieldrin.

At the low end, the colonies of Pt. Colborne and/or Middle Island in Lake Erie had, with two exceptions, the lowest rankings for DDE, DDT, dieldrin, HCB and mirex. PCBs were lowest in colonies of the upper lakes.

For mirex residues, Mugg's and Snake Islands had levels statistically ($P<.05$) higher than the rest of the colonies in all four years, and the highest PCB levels in three years.

For each year and residue, colonies were ranked according to their level of contamination. By giving the rankings for all residues equal weight, an overall ranking was computed for each colony and hence for each lake. Lake Ontario colonies were the most contaminated, followed by those on Lakes Huron and Superior, with Lake Erie colonies the least contaminated. Other residue data indicates that if Lake Michigan were added to this comparison, it would supercede Lake Ontario as the most contaminated lake (Gilman et al. 1977a, CWS unpublished data for 1978).

Reproductive Success

Reproductive success figures for the Monitor Colonies during the period 1974–1978 are presented in Table 4.

In 1974, both the Pt. Colborne Monitor Colony and the nearby Canada Furnace Colony in Lake Erie had low fledging success (less than .5 young/pair). Lower yet was Scotch Bonnet Island (a colony approximately 50 miles (80 km) distant from the Snake Island Monitor Colony in Lake Ontario) in 1975. At the same time, however, colonies in Lakes Huron and Superior exhibited normal fledging success (greater than .8 young/pair). All of the Monitor Colonies as well as Scotch Bonnet Island had "normal" fledging success in 1977 and 1978.

We conclude that herring gull colonies in both Lake Ontario and Lake Erie have shown dramatic improvements in breeding success over the last five years. Lake Huron and Lake Superior have remained stable during that time period.

Discussion

Residue Levels

The herring gull has a wide distribution throughout the holarctic. The organochlorine levels present in Great Lakes herring gull eggs are extremely high

Table 4. Fledging success at monitor and nearby colonies.

	1974	1975	1976	1977	1978
Lake Erie					
Pt. Colborne	.48[a]	.65[a]	.79[a]		1.45
Middle					1.7
Canada Furnace	.32[a]				
Lake Ontario					
Snake				1.01[c]	.86*
Mugg's Island				1.52[d]	1.47[d]
Scotch Bonnet		.15[b]		1.10[c]	1.01*
Lake Huron					
Chantry Island		1.48[b]		1.12[c]	1.4
Double Island					1.57
Lake Superior					
Granite Island		1.32[e]	1.55[e]		1.12
Agawa Rocks					1.66

[a]Morris and Haymes 1977—use 30 days to "fledging," these data are not strictly comparable but are not thought to differ greatly.
[b]Gilman et al. 1977.
[c]International Joint Commission 1977.
[d]Fetterolf (personal communication).
[e]Ryder and Carroll 1978.
*Minimum values, determined from one visit only. Values based on a single visit on unfenced colonies usually underestimate the fledging success by 25–40 percent.

for any aquatic feeding species. Residue levels for herring gull eggs in any other part of Canada are between 5 and 10 percent of the mean PCB and DDE values reported here (Vermeer and Peakall 1976). High values reported for black-headed gull (*Larus ridibundus*) tissues from the Sea of Japan were 50 percent lower than mean Great Lakes values (Fujiwara 1975). Norwegian herring gull eggs exhibited much lower levels of PCBs, accumulating only several ppm (Bjerck and Holt 1971). Herring gull eggs from the Baltic Sea are the only samples which approach Great Lakes values at 62 ppm PCB and 38 ppm DDE (Jorgensen and Kraul 1974). From evidence presently available, Great Lakes herring gulls suffer from the highest organochlorine contamination level known for the species.

Residue Trends

Since the late 1960s, the use of DDT, PCBs and several other environmental contaminants has been restricted in Ontario and much of North America (Frank et al. 1978b). The rate of decline in the residue levels in the herring gull eggs can be attributed to a relatively rapid elimination of these toxic chemicals from the Great Lakes aquatic ecosystem through biological degradation, evaporation and sedimentation (Bierman and Swain 1978).

The declines observed in the eggs of the herring gull are presumably a result of decreased residue levels in the diet of the birds. On Lakes Erie and Huron, the fish diet of the herring gull is composed almost exclusively of alewife (*Alosa pseudoharengus*) and smelt (*Osmerus mordax*) (Allan 1977 and unpublished data). Definitive trend data for contaminant levels in these fish species are not available. Frank et al. (1978b) have shown that for alewife and smelt from Lake Huron, levels of PCBs and DDE in 1976 were lower than in 1970. Similarly, in Lake Erie, 1976 values were lower than those from fish taken in 1971 (Frank et al. 1978a). However, these conclusions are based on only small point samples and do not necessarily indicate statistically valid trends. Bierman and Swain (1978) have presented data which they extrapolate to show a drastic decline in (total) DDT levels in fish populations with low body fat in all five Great Lakes. Smelt would fall into this category.

The half dozen organochlorine residues considered in this paper, although amongst the most prevalent in modern aquatic environments, represent a small proportion of the number of chemical pollutants present in wildlife. Intensive analysis of adult herring gull lipid and eggs has revealed other organochlorines as well as non-chlorinated aromatics and heavy metals. The complete list of organochlorines found in herring gulls to date may be subdivided into: (1) agriculturally related contaminants: DDE, DDT, DDD, DDMU, BHCH, alpha chlordane, oxychlordane, heptachlor epoxide, methoxychlor and dieldrin, and (2) industrial contaminants: PCBs and PCB-OH metabolites; mirex, photomirex and other mirex dechlorinated derivatives; di-, tri-, tetra-, penta- and hexachlorobenzene; tri- and tetrachloroethylenes and chlorinated styrenes (Hallett et al. 1977a, 1978, Norstrom et al. 1978). Polynuclear aromatic hydrocarbons originating from the combustion of fossil fuels were also found at low levels in adult lipid from Ontario gulls (Hallett et al. 1977b). Heavy metals were also evident, principally mercury and lead in eggs but also cadmium, chromium, selenium and other elements in feathers were evident (unpublished data).

Reproductive Success

The dramatic improvement in the reproductive success of herring gulls between 1974 and 1978 in Lakes Ontario and Erie is directly paralleled by equally dramatic decreases in the major organochlorine residues. Data collection on reproductive success to data has not been consistent enough to establish a correlation between these two parameters. We are presently continuing an annual three-point assessment of reproductive success using a standardized technique in order to examine this correlation accurately.

Gilbertson (1974) documented the reproductive success and contaminant levels on several herring gull colonies in Lakes Ontario and Erie in 1972. While trends of organochlorine residues have been well monitored in avian species since before the time of restricted contaminant use, trends in quality of life measures, e.g., eggshell thickness, embryonic mortality, hatching and fledging success, abnormal behavior, etc., have not been as well monitored. Although eggshell thinning is the reproductive parameter most often associated with organochlorine contamination of avian species, these effects are minimal in herring gulls (Pearce et al., in press). Anderson et al. (1975) have reported declining DDT-related residues in California brown pelican (*Pelecanus occidentalis*) and in their main food, northern anchovies (*Engraulis mordax*), simultaneous with increased pelican fledging success and eggshell thickness. Cooke et al. (1976) have reported indications that egg residues of DDE and other organochlorines are decreasing in England and that shell thickness and incidence of shell breakage in the grey heron (*Areda cinerea*) are returning to normal. Postupalsky's studies in the Great Lakes (unpublished data) show increasing reproductive success and eggshell thickness for double-crested cormorants (*Phalacrocorax auritus*) along with decreasing DDE egg residues. Mendenhall (in press) has reported declining residues in South Carolina populations of brown pelican followed by improved hatching success, increasing eggshell thickness and increasing breeding numbers.

Summary and Conclusions

1. Herring gull eggs were monitored for levels of the major organochlorine residues in two colonies from each of Lakes Ontario, Erie, Huron and Superior during 1974, 1975, 1977 and 1978. Colonies of Lake Ontario were the most contaminated followed by Lakes Huron and Superior with Lake Erie as the least contaminated. Since 1974 significant decreases were evident in levels of DDT, mirex and PCBs, at all colonies and most colonies showed similar decreases for dieldrin, DDE and HCB. One significant increase was noted for DDT for Granite Island (Lake Superior) between 1977 and 1978.
2. Half-lives for mirex (1.9 to 2.1 years) were calculated for the Snake and Mugg's Island colonies on Lake Ontario. These were taken from significant fits of mirex residue trends to a log-linear regression model. Other half-lives calculated in a similar fashion were 3.3 years for DDE on Mugg's Island (Lake Ontario) and 2.4 years for HCB on Mamainse Island (Lake Superior). Log-linear model decreases were also used to extrapolate years of non-detection for these residues. They were 1992 and 1994 for mirex on Mugg's and Snake Islands respectively, both on Lake Ontario, 2012 for DDE on Mugg's Island (Lake Ontario), 2037 for PCB on Granite Island (Lake Superior) and 1986 for HCB on Mamainse Island (Lake Superior).
3. Reproductive success of herring gulls was determined on all colonies in 1978 and on selected colonies prior to that. Reproductive success has shown a substantial improvement on Lakes Erie and Ontario. It was directly paralleled by a decline in the major organochlorine residues. Reproductive success on Lake Huron and Lake Superior has remained relatively high.
4. Continued monitoring of residue levels and the reproductive success of herring gulls will serve to indicate trends in contamination by persistent toxicants and in the overall health of the Great Lakes ecosystem. Trends from 1974 to 1978 show a general improvement.

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Changes in Species Composition of Great Lakes Fish Communities Caused by Man

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Introduction

We are at least five years and perhaps ten years away from a reasonably complete understanding of the topic of this paper. But some of the general features of when, how and why the Great Lakes fish communities have changed due to man's activities are coming clear. My objective now is to sketch hypotheses and a conceptual framework that might prove useful in attempts to integrate our understanding of inadvertent changes of the past and of more deliberate changes of the future.

The number of scientific papers quite directly relevant to important aspects of our topic has been growing at something like an exponential rate. The doubling time of the number of significant papers may be about 10 years. A list of 100 particularly significant papers could readily be assembled. Perhaps another 100 will be produced in the 1980s. The sooner the researchers produce an integrated and detailed account of the fish community changes, whatever its shortcomings, the higher the quality will be of subsequent work.

Several symposia have been convened in recent years that have dealt witn the ecology of families and associations of fish species that have responded to man's varied and ubiquitous influences. Those that have some immediate relevance to the Great Lakes include symposia on coregonines (Lindsey and Woods 1970), salmonids including both salmonines and coregonines (Loftus and Regier 1972), centrarchids (Stroud 1975), percids (Colby 1977) and cool-water associations involving esocids as well as other taxa (Kendall 1978). The list will be augmented in 1979 with a Great Lakes-oriented lamprey symposium and in 1980 with a "stock concept" symposium that will focus again on salmonids and percids.

Meanwhile numerous other symposia, reference groups, workshops and collaborative studies have addressed other aspects of the Great Lakes ecosystems and their responses to man's activities. Particularly noteworthy are the Great Lakes Basin Commission's Framework Study and the International Joint Commission's Pollution from Land Use Activities Reference Group, PLUARG (Berg and Johnson 1978). The Great Lakes Fishery Commission (GLFC) helped to sponsor several of the symposia listed earlier and is the lead agency in the lamprey and stock concept symposia scheduled for 1979 and 1980. GLFC has also funded a Feasibility Study of Great Lakes Ecosystem Rehabilitation and Restoration, GLERR, which will be reported to the Commission in June 1979 (see Magnuson and Regier 1978—a draft report.)

With this great wealth of information in the form of many partial analyses it seems feasible now to take seriously a challenge to understand the Great Lakes from an ecosystemic, holistic viewpoint. That is the perspective of our GLERR study to which a score of colleagues have made important contributions.

Baseline Conditions Two Centuries Ago

Because we are terrestrial beings, humans have only a very partial natural appreciation of the workings of aquatic ecosystems. Even in areas where we directly perceive that degradation has occurred we have only a dim sense of the nature and extent of the degradation, unless we resort to scientific study. An effective start toward gaining a better appreciation of our impacts involves a comparison of selected present features of those ecosystems with comparable features two centuries ago when our impact on those ecosystems was comparatively slight.

The extent of nearshore wetlands, coastal marshes and nearshore macrophyte beds was much greater in the natural state than in the present state of economic development and/or relative degradation.

Streams and rivers flowed cool and clear in summer with far less seasonal fluctuation in flow than at present. Salmonids spawned in them.

The nearshore ecological community in sheltered bays and island clusters was in the form of a luxuriant mosaic with macrophytes,numerous large invertebrates such as molluscs, crustaceans and insects and many large fish such as muskellunge, pike, sturgeon, smallmouth bass, etc. Various mammals such as moose and muskrat used those areas extensively.

Reefs and areas of mid-depth, say 4 m to 12 m, were extensively used for fish spawning and served as the preferred habitat for larger percids and ictalurids in summer, and of salmonids in spring and fall.

The deepwater community contained large semi-benthic zooplankton and a complex association of coregonines and salmonines, especially in summer.

The offshore surface waters had a rather sparse plankton community, some small shiners and were comparatively clear. In areas near eroding clay bluffs the water was of course turbid then much as it is now.

The ionic composition was dominated by the carbonate-bicarbonate series with a gradual enrichment from north to south. The streams that drain the igneous Canadian Shield contribute little compared to those that drain the limestone regions further south. The chloride content was very low in the lakes at that time.

Organic sediments did not accumulate, that is they were fully oxidized through biotic or chemical means, except in some marshes, bays and perhaps in a few deep basins. Except perhaps in a few very local areas, the oxygen concentration remained high at all times of the year.

With respect to rooted aquatic plants, benthic animals, fish, reptiles and the mammalian frequentors of wetlands, a large part of the biomass consisted of older, larger individuals of large-sized taxa. For example, it seems reasonable that over 50 percent of the total biomass of all fish was contributed by those individuals each over 5 kg in weight.

The Great Lakes then contained no Pacific salmon species, brown trout, rainbow trout, Atlantic salmon (except Lake Ontario), nor alewife, rainbow smelt, carp, goldfish, white perch, and sea lamprey (again except perhaps in Lake Ontario). They contained unique species or subspecies that are now extinct such as the blue pike, Michigan grayling and some coregonines. Scores of distinctive, locally-adapted stocks of salmonids and percids that once existed have since been obliterated.

Two centuries ago the lake levels fluctuated gradually due to climatic precipitation trends, much as they do now. When furious storms coincided with high water, barrier bars across the mouths of bays were occasionally broached. The ecology of the bay would then be modified markedly due to this natural impact, until such time when the break would have mended naturally. Ecological communities typical of such peninsulas and bays are quite resilient to even major natural calamities (see Nelson and Needham 1978).

Human Activities That Have Altered the Fish Associations

Participants in a GLERR workshop (Toronto, January 17–20, 1979) developed a listing and classification of human activities that have influenced the fish associations as well as other components of those ecosystems. Space here does not permit more than the briefest of annotation. The major point to be noted is that many activities have influenced the fish associations and almost always in a way that reduced the quality of the yields of this resource.

Stresses Directly Related to Fish

(i). Fishing, Whether Sport or Commercial. The classical fishing-up process occurred in the Great Lakes in that the largest individuals of the largest species were removed first. Eventually almost all the fish above 1 kg were removed and the fishery thereafter was prosecuted in a way that permitted few fish to survive beyond the age at which they reached 1 kg. In many areas the fishing-up process proceeded until relatively few fish exceeded 0.2 kg. (The sea lamprey, with much the same species and size preferences as humans, as well as other stresses, assisted in the fishing-up process comparatively late in that process.)

(ii). Invasions of Exotic Biota through Canals. The story of the consequences of sea lamprey's entry into the upper lakes by way of Welland and/or Erie Canals is well known. The alewife's invasion may have been almost as deleterious. The white perch is currently on the march. All are consequences of a decision to build canals for commercial purposes. Incidentally, the fishermen who suffered as a result of those decisions were not effectively compensated for their losses.

(iii). Introductions of Exotic Biota. Fishery managers introduced the European carp into the lakes in the 1880s and rainbow smelt into the watershed in the 1910s. Their impacts are not fully understood. Commercial fishermen have found ways to capture and market them. Quite a number of salmonine species have been introduced almost entirely to serve angler interests. The pelagic coho salmon was chosen by Michigan to order to prey upon the alewife as a pelagic pest; the kokanee by Ontario to feed directly on plankton and compete with alewife and smelt. The pink salmon now spreading through Lake Superior and the lower lakes was an "accidental" release. Rainbow trout were planted in order to utilize natural stream spawning and rearing capabilities.

(iv). Entrainment and Impingement in Water Intakes. Countless numbers of the young of various species of fish as well as adults of the more pelagic forms are killed as a result of water intakes for industrial and domestic purposes. The extent of impact is under debate (Van Winkle 1977).

(v) Thermal Outfalls. Some industries, especially electric power plants, recycle vast quantities of warmed water into the lakes. Beyond the entrainment and

impingement effects, the influence of the heated water in the environment is still under debate. Smallmouth bass which are near their northern limit in the Great Lakes may on balance benefit from the warm water (Shuter et al. 1979). Other, stenothermic species that used to frequent such areas may suffer from the presence of warm water perhaps by effective exclusion from traditional habitat or by having migratory paths barred and sequences disrupted.

Nutrient Related Stresses—Eutrophication

(i). Chemical substances used as raw materials for photosynthesis lead eventually to enhanced production of pelagic phytoplankton if the loading rate increases with time. With excessive enrichment macrophytes are shaded out and large fish predators such as pike and muskellunge disappear. Their prey species may then thrive.

(ii). As nutrient loading intensifies more of the nutrients reach offshore surface waters where an augmented planktonic community becomes sufficiently rich to support some pelagic species such as yellow perch which then thrive. This species is seldom found offshore in pelagic waters in oligotrophic lakes.

Other pelagic fish species such as alewife and gizzard shad also benefit from the increased plankton production. If sufficient pelagic fish can then be produced, a new niche for a pelagic piscivore is created, e.g. the Pacific salmon.

(iii). If eutrophication becomes very intense, the positive feedback process by which oxygen of the hypolimnetic waters becomes exhausted is triggered. In the extreme case, all stenothermic fish species are then excluded during the critical summer period and are extinguished in that lake. This has occurred with lake whitefish, lake herring and blue pike in the Central Basin of Lake Erie.

Stream Alteration

Some valued fish species or some of their stocks migrated into streams to spawn. The Atlantic salmon was endemic to Lake Ontario and disappeared over a century ago. Strong circumstantial evidence points to the damming, siltation and warming of the spawning streams as the proximate factors in their extinction.

Stocks of lake trout, lake whitefish, walleye, sauger and other species throughout the Great Lakes spawned in tributary streams. Most of those spawning runs have been destroyed with a consequent impoverishment in the genetic and ecological complexity of the fish associations.

Toxic and Microcontaminant Stresses

(i). Incidents of gross poisoning as a result of industrial wastes carelessly disposed into those waters were common from the mid-1800s to the mid-1900s. A local furor sometimes ensued with a result that the grossest features of the poison-loading practice were discontinued. No fish species seems to have been exterminated as a result. Some fish stocks may have been destroyed, but I do not know of any documentation in support of that conjecture. Certainly fish taken locally could not be sold if their flavor was offensive, as with phenol contamination. Fishermen again were usually not compensated, or only to a very inadequate extent.

(ii). The microcontaminant problem is largely one of human health. Concern about those substances has resulted in regulations that seriously contaminated fish not be marketed. To the disadvantage again of the fishermen, but occasionally to the advantage of fish, fewer fish were then harvested. In Western Lake Erie, walleye contaminated with methyl mercury were thus protected at least in part and a rebound of the population has occurred. Earlier analyses had convinced fisheries researchers that this stock had been severely over-fished (Regier et al. 1969).

Major Physical Alterations

(i). Water level controls. Depending upon the level at which lake levels are controlled, the amount of shoreline erosion may be reduced and with it the extent of clay turbidity. The latter has an adverse influence on the productivity of waters, including their production of fish.

If high water levels are prevented in the future then the periodic rejuvenation of certain bays such as Inner Long Point would not likely occur. Gradually such bays might become silted and weed choked, with occasional anoxic events deleterious to fish such as pike and bass.

If attempts to control water levels lead occasionally to higher water levels than would have been the case naturally, then the converse of the above events could be expected to happen.

(ii). Canals and diversions. As already indicated above, these provide invasion routes for nonendemic species. Invasions by sea lamprey, alewife and white perch are well known. Presumably other fish species that do not yet occur in the Great Lakes will in the future use the canals to invade them. Apparently no one has hazarded a guess as to which species might be the next to appear.

Of growing concern is the epizoological process by which pathogenic organisms spread across our continent. There are numerous hotspots of virulent fish diseases scattered across the countryside. Presumably canals will expedite the spread of some of these.

(iii). Shoreworks, dredging, dumping, sedimentation and infilling. Harbor and dock construction tends to occur in those areas that are among the most valued from a fish production viewpoint. Fish species particularly valued by anglers and now reserved for them are most severely affected. Low valued, tolerant fish then dominate the harbor waters, unless they are too severely degraded by related industrial and shipping wastes.

Dredging, dumping and so on are practiced in relatively shallow waters that are among the most productive for large percids such as walleye and sauger, as well as ictalurids like channel catfish. A modest amount of turbidity caused by these practices may benefit the light-sensitive large percids. Large amounts lead to the reduction of productivity of the waters with respect to fish food. Excessive amounts greatly reduce the efficiency of food capture by sight-feeding fish such as walleye.

(iv). Wetland destruction. Pike and muskellunge as well as some other species spawn on flooded wetlands and marshes. These areas then serve as nursery habitat for the young which subsequently enter permanently deeper areas with the receding waters. Often macrophyte beds occur in those waters next to marshes.

The draining and dyking of such areas removes marsh habitat and also leads to the reduction of macrophyte beds on the lake side of the new dykes. Both lead to a great reduction of esocids, for example in the southwestern area of Lake Erie early in this century.

(v). Sand, gravel and rock extraction. Inshore and underwater deposits of those materials near settlements have long been used for construction purposes. The gravel and rock beds in some cases were spawning habitat for salmonids and percids. Large stretches of the shoreline and nearshore waters of Western Lake Ontario were denuded of large rocks by "rock grabbers" decades ago (Whillans 1977). There is circumstantial evidence that the suitability of some reefs for lake trout spawning was destroyed in this way.

(vi). Waves and currents due to shipping and boating. Many localized, naturally protected areas have been colonized by pleasure boat owners. The high speed movement of boats, together with petroleum and other wastes, tends to change a protected lake-like habitat into something a little more like a degraded stream habitat. Presumably this acts directly to the disadvantage of bass. Indirectly, macrophytes are adversely effected, presumably to the disadvantage of pike.

Large vessels plowing through channels and rivers create waves and currents along nearby shores that keep the "state of succession" to an "early" and rather undesirable type. Few valued fish can be expected to be found in such locales.

(vii). Modification of ice regimes. If management of ice cover results in the build-up or pile-up of ice thickness inshore, the nearshore association will likely be adversely affected through massive abrasion of the substrate. If so, an effect will be to keep more of the nearshore community in a physically stressed state than was previously the case, to the relative advantage of small, low valued fish species.

Catastrophic Events

Many of the above kinds of stresses can build incrementally and gradually. Or they can occur catastrophically on occasion. In some ways a massive catastrophic event differs qualitatively from a long-term incremental process, both ecologically and politically. Certainly they are dealt with very differently politically.

We know relatively little about the impacts of major oil spills on fish associations like those of the Great Lakes. Or of possible major leaks of radioactive material from nuclear power plants, or of possible major spills of highly poisonous materials transported in great quantity over all the Great Lakes. We can expect the major effects of such catastrophes will be uniformly deleterious to the quality of the fish association, that the fishermen will suffer the consequences and that they will not receive just compensation.

Present Conditions

A watershed and lake ecosystem may be perceived as comprising four major components: the tributary streams; the coastal zone including nearshore littoral; the offshore, deep hypolimnetic waters and benthos; and the offshore, near-surface, epilimnetic communities. Again some minimal annotation will have to suffice here.

Tributary Streams

Distant from urban areas, there are many ecologically healthy tributaries to the Great Lakes. Those near settlements tend to be most degraded at or near the mouth, with less degraded reaches further inland. Thus settlements tend to break ecological connections between the lakes and upstream habitats to the disadvantage of stream spawning and migratory species.

During the 19th century many hundreds of dams were located on Great Lakes tributaries to harness water power for mills of various sorts, to dam up water to supply industry and settlements, to feed canals, etc. Many of those dams have since crumbled and thus this kind of major stress has been gradually relaxed. Valuable spawning runs of salmonid species have been re-established in some of them.

Great Lakes ecologists and managers have not paid sufficient attention to the effect of stream uses and abuses on Great Lakes processes, as the PLUARG reports clearly demonstrate. Much remains to be done.

The sea lamprey control program involves poisoning the ammocoetes in the mud of streams. This sometimes involves death of other fish species as well as other biota. GLFC is seeking to perfect ecologically more sensitive ways of coping with the sea lamprey pest.

The Coastal Zone

In the primeval Great Lakes of two centuries ago, the estuaries, bays, bars and nearshore reefs seem to have figured importantly in the life cycle of almost all of the valued fish species. Often the spawning and early life history stages occurred there. For many species the ecological requirements for successful reproduction are quite strict (Balon et al. 1977). Today many of these traditional reproductive habitats no longer prove viable for the stocks.

In any listing of the most severely degraded areas of the Great Lakes basin, the great majority are located in the coastal zone. From ecological, aesthetic and economic viewpoints these locales were once among the most important in the Great Lakes. In the last few decades these locales have been largely ignored by planners, managers and researchers. What a curious combination: most valuable, most degraded, most ignored!

The Offshore Hypolimnetic Associations

The salmonines, coregonines and larger percids have long dominated the interests of fisheries managers and researchers. Those species dominate the deeper waters, at least during the period of summer stratification. Large percids can survive warm surface water, though they do prefer cool deeper waters.

All through the Great Lakes the deepwater fish associations are currently in a very degraded state, though some recovery is evident from a deep low a decade ago. Better fisheries policies, sea lamprey control and restocking are largely responsible for the improvement. The improved controls on nutrient, poison and contaminant loading have made little direct contribution to the recovery of these stocks, partly because these kinds of stresses were not directly responsible for some of the historic degradation of the deep off-shore species in the upper Great

Lakes. Where some of these stresses were involved in the lower lakes the control and recovery process seems not yet to have reached a point where a recovery of the hypolimnetic fish stocks is apparent.

The Offshore Epilimnetic Waters

These waters are now luxuriant in planktonic production in large areas such as Green Bay, Saginaw Bay, Western Lake Erie, and several inshore parts of Lake Ontario. They are now dominated by small, short-lived pelagic fish like alewife, gizzard shad, freshwater drum, and to a lesser extent smelt, white bass and yellow perch.

The primeval Great Lakes contained no large pelagic piscivores. The emergence of a large biomass of small pelagic clupeids and osmerids provided incentive to introduce large pelagic salmonids, like Pacific and Atlantic salmon and rainbow trout. Thus the lakes today contain a pelagic association, made up mostly of exotics that simply did not exist two centuries ago. An open-lake salmon sport-fishing clientele has developed that would presumably be adverse to strict anti-eutrophication programs if a consequence of such programs were that this exotic pelagic association were to be severely depressed. Some fishery managers nourish a hope that this clientele would become interested in rehabilitated native salmonids which might again thrive with a reduction in state of eutrophy as well as other stresses such as lamprey predation and overly-intense commercial fishing.

In summary of this section I suggest that the locale of ecological dominance has shifted during the past century. The large "k-selected" fish species that once dominated the fish association were closely related to the coastal, nearshore zone. Currently large areas of the lakes are dominated by an offshore association of "r-selected" exotics. In some parts, especially in the upper lakes, the fish association seems to be impoverished in that the "k-selected" species have been greatly reduced in abundance, but "r-selected" species have not increased notably.

With the great increase in production of plankton and abundance of pelagic fish in large parts of the lake it would seem reasonable to suppose that a large increase in commercial catch of fish should have occurred. This has not been the case—the total catch of fish in the Great Lakes peaked early in the present century.

Several of the small species are almost worthless economically, i.e. worth only several percent of the large valued species, on a per unit weight basis. Also it seems that the ecological production of small pelagic fish is not vastly greater than was the case with large benthic taxa which once dominated the lakes. This runs counter to some widely-held, overly simplistic intuitions of trophodynamic ecologists. The latter have often put more faith in an intellectual creative abstraction than in direct holistic observation.

Concluding Statements

Overall the change in the fish associations in the Great Lakes during the past two centuries has involved a massive shift from high-valued, large, long-lived, benthic species to low valued, small, short-lived pelagic species. Though fishery enterprises, both commercial and sport, have found ways to use some of the species that are currently dominant, a return to the earlier association is generally held to be a desirable goal on economic grounds. But what the relative economic benefits would be has not yet been fully assessed (see Magnuson and Regier 1978, Kuchenberg and Legault 1978).

The long list of stressful human activities presented in a preceding section have often interacted additively or even synergistically to effect the overall transformation of the fish association. I attach a lot of importance to that inference. It helps to explain why all the piecemeal and uncoordinated attempts to "manage" the Great Lakes fisheries heretofore have been relatively ineffective. Presumably a similar reason underlies the lack of significant progress in the Great Lakes clean-up program, where qualities other than the relative value of fish stocks are of primary consideration.

Sooner or later—much as they may work to resist it—the senior bureaucrats who now control the Great Lakes clean-up program will have to come to terms with a more holistic approach. The prospects for the rehabilitative recovery of these lakes may then improve dramatically.

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Native Peoples and Natural Resources Management

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Alaska encompasses some 586,000 square miles (375 million acres; 153.4 million ha) of land containing bountiful known natural resources within an essentially pristine environment, plus some unknown magnitude of resource wealth yet to be identified. In addition, the territorial sea and submerged lands along a 30,000 mile (48,000 km) coast also contain substantial resource values. The Alaska Lands "(d)(2)" legislation now being debated in the Congress will decide how the lands will be divided among the federal government, the state, and the Alaska Natives and to great extent how the natural resources of the state eventually will be managed. Central to and actually a basis for this lands issue is the Alaska Native Claims Settlement Act (ANCSA), signed into Federal law on December 18, 1971.

The Settlement Law

The Alaska Statehood Act of 1958 gave the new state the right to select 104 million acres (42.5 million ha) of Federal lands, and among other provisions explicitly identified the state as the primary authority for managing the fish and resident wildlife resources within its boundaries. Statehood accelerated the "Native Claims" issue during the early 1960s, and was a major factor in prompting Secretary of Interior Udall in 1966 to impose a "land freeze" on all unreserved federal lands in Alaska. The discovery of one of the largest oil fields in the world in 1968 on the North Slope further intensified the pressure on Alaska's land. The intent of the 1971 Settlement Act was to provide the necessary framework for resolving native claims, for addressing the state's land entitlement, for land-use planning, and for protecting environmental values. Section 17 (d) (2), which directs the Secretary of the Interior to withdraw up to 80 million acres (32.7 million ha) of land for conservation purposes, has been the primary focus of the so-called "(d) (2) legislation" now before the Congress.

Under the law the Alaska Natives—a "native" being defined as a person of one-fourth degree or more Alaska Indian, Eskimo, or Aleut blood—will receive about 44 million acres (18 million ha) of land and about $1 billion. It provided for the establishment of Regional Corporations (now numbering twelve geographical regions) comprised of Natives having a common heritage and sharing common interests to utilize the Act's benefits for the purpose of conducting business for profit. In addition, each Native village within a Regional Corporation was organized into a Village Corporation. The Act established a system of land allocation to each Native village based upon population size and to each Regional Corporation. The subsurface estate belongs to the Regional Corporations, except for certain Native selections in Federal reserves such as wildlife refuges. In essence, once the land is conveyed these 44 million acres of Native lands are simply "private lands," unless future Congressional action should modify the present situation.

There are a number of policy statements and specific provisions in the law that are relevant to this discussion and should be pointed out.

1. There is an immediate need for a settlement of aboriginal land claims. Such settlement is predicated on the aboriginal use and occupancy of lands rather than on the use of resources.
2. The settlement should be accomplished rapidly in conformity with the real economic and social needs of Natives, with maximum participation by Natives in the decisions, without establishing any permanent socially defined privileges, without creating a reservation system or lengthy wardship or trusteeship, and without adding to the legislation establishing special relationships between the United States Government and the State of Alaska.
3. No provision of the Act shall replace or diminish any right, privilege, or obligation of Natives as citizens of the United States or of Alaska or relieve, replace, or diminish any obligation of the United States or of the State of Alaska to protect and promote the rights or welfare of Natives as citizens of the United States or of Alaska. This policy statement is particularly relevant to the continuance of subsistence hunting and fishing on the Fderal lands.
4. All aboriginal titles, if any, and claims of aboriginal title in Alaska based on use and occupancy, including submerged land underneath all water areas, both inland and offshore, and including any aboriginal hunting or fishing rights that may exist, are extinguished.
5. With certain exceptions all lands identified as potential Native lands are withdrawn from all forms of appropriations, including State selection.
6. Easements are to be provided to accomodate full right of public use and access for recreation, hunting, transportation, utilities, docks, and other public uses.

Implementation

Many delays have ensued since the Act was passed, and implementation has proceeded slowly in the midst of litigation; land selection and conveyance problems; battles involving "environmentalists," Natives, "developers," politicians, and bureaucrats; Congressional review and investigation; and the attempt to solve it all by passage of "(d) (2) legislation"—currently labeled the "Alaska National Interest Lands Conservation Act." The main thrust of the legislation has been environmental, with state land selections and Native claims and Native land selections somewhat secondary. Some lands have been conveyed to the Native Regional and Village Corporations, but the process is slow and procedurally complex. The total selections by the Natives far exceeded the total allotment of about 44 million acres, and therefore considerable negotiation remains necessary.

In the language contained in ANCSA is adhered to during the implementation process, there should be relatively few problems that can be attributed specifically to Native claims or privileges. Alaska will not suffer from the reservation/treaty problems of the "Lower 48." Alaska Natives will be private landowners subject to the same constraints as other citizens. As noted earlier, all aboriginal claims in Alaska supposedly will be extinguished once the law has been fully implemented, except of course for whatever implicit responsibilities for aboriginal peoples the federal government may retain relative to the Constitution and to previous legal agreements and decisions. The main complications yet to be faced will concern the management of Alaska's lands and resources after land conveyance to the various land authorities has occurred—i.e., State of Alaska, Alaska Natives and other private citizens, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, and the Forest Service. The (d) (2) legislation eventually passed will determine how complicated the resource management problem will become. Of particular importance and interest in this legislation has been the management of Alaska's fish and wildlife resources, and the significance of providing for the subsistence needs of Alaska Natives and other rural residents in Alaska.

Subsistence and the Alaskan Way of Life

The Alaska Natives have pushed strongly to include a "Subsistence Title" in all the proposed (d) (2) legislation, and the State of Alaska supports this effort *except* for federal overview authorities on state management. The language would mandate the continuance of subsistence hunting and fishing by rural residents—*all* rural residents, not just the Natives—and would establish subsistence as the priority consumptive use of our fish and wildlife resources. There is little question that this issue has been one of the most emotional of all the issues being addressed, nor that there will be substantial impacts upon the future management policies concerning the human utilization of these resources.

The question of "subsistence" is complex. What is "subsistence?" Who are "subsistence users?" Is the commercial salmon fisherman who year after year derives his *entire* livelihood from his catch of salmon a "subsistence user?" What of the Eskimo who kills walrus for food and hides, but uses ivory to provide for his needed cash? What of the Yukon Indian who takes salmon for his subsistence "food needs" and additional fish for roe to supply his subsistence "cash needs?" What of the villager who traps commercially for fur?

"Subsistence" is a spectrum of uses at best, quickly overlapping recreational and commercial uses from year to year, seasonally, or even daily. In numerous parts of Alaska, there are fishermen who take salmon, herring, and other species for commercial purposes and also take them for subsistence purposes. In some form or another, living-off-the-land permeates almost every Alaskan lifestyle with varying degrees of dependency—whether a person lives in rural villages such as Koyukuk, Shageluk, Emmonak, Ninilchik, and Hoonah or in such urban communities as Juneau, Homer, Anchorage, Palmer, and Fairbanks.

A prevailing idea in the "South 48" that all existing subsistence needs and endeavors and the present mechanisms for harvest are and should remain primitive is erroneous. All of the modern conveniences—airplanes, snowmobiles, motorboats, efficient weapons, modern houses—have removed most of the "primitiveness" from the old so-called subsistence lifestyle that once was. Yet the need for such utilization of our fish and wildlife resources continues, and many Alaskans depend upon these for their livelihood.

Unfortunately, there never have been any subsistence guarantees, and it is pure folly to expect that such guarantees can be provided today. Most renewable resources are affected by a variety of factors which may affect their availability on any given day, during any month, year, or decade. This variance is especially true of our fish and wildlife populations, which fluctuate in numbers and availability through time. For one to experience a stable dependency on these resources, there must be a cognizance of the need for diversity and good management. Today this diversity can be provided only by examining all the options and not by limiting any consumptive use to any given parcel of land. Fish and wildlife know no boundaries and are part of an ecosystem that must be managed in its entirety. Any fragmentation of management authority as could result from (d) (2) legislation seriously hampers effective conservation efforts and the ability to provide for continued subsistence use.

State Actions Affecting Subsistence Use

The governor, the state legislature, and my department have recognized fully the needs of rural peoples for fish and wildlife resources. It is significant that the governor's policy and that of the boards of fisheries and game for some years has been and remains that "subsistence use" is the priority use among the various consumptive uses of our fish and wildlife resources. This priority recently became established in state law by action of the legislature and the governor last July. Concern for rural people's needs in Alaska for fish and wildlife has been in evidence since statehood, and was recognized even before that by the old Alaska Game Commission inder the territorial and federal government system. It is important to note that Alaska Natives have received no special privileges, nor have they requested any ethnic privileges.

The history of state regulations is instructive in assessing what legal provisions have been made for subsistence-type uses. After statehood, increased bag limits, either-sex seasons, and extended seasons were allowed, especially in rural areas where limited access constrained urban or suburban hunters from visiting. A typical liberal example of providing for subsistence needs relates to the caribou regulations north of the Yukon River where for many years no-closed-season and no-bag-limit regulations for the local residents were in effect. In many "bush" areas, moose seasons lasted through the winter, or a later winter season was instituted, so that moose could be taken after meat supplies from the fall hunting period were done and at a time of year when meat spoilage was no problem. No seasons or bag-limits were placed on the taking of most marine mammals and of most finfish and shellfish—these animals constituting more than 80 percent of the subsistence needs of the Native peoples in Alaska. Even today, in spite of greatly increased demands upon our fish and wildlife resources, most of these aquatic species can be taken with no or few restrictions. These various considerations, I feel, demonstrate that the state indeed has been and continues to be concerned that local needs are met, and has attempted to provide for them in one way or another since 1959. In reality, only a few species are problems—namely, moose, caribou, king salmon, walrus, and bowhead whale.

Nevertheless, in the Congress and among certain "outside" groups there has been great concern that the state's fish and wildlife management programs have not provided adequately for "subsistence" uses and especially for Native peoples. It is true that problems have arisen and at times persisted, especially when some desirable species was in short supply. Everyone recognizes, however, that protection of the resource base has top priority. When some species populations are low, for whatever reason, it becomes necessary to restrict or even prohibit *all* consumptive uses of those species until the populations recover. Certain populations of moose and caribou presently are in that situation.

The recent state law now in effect defines "subsistence uses," "subsistence hunting," and "subsistence fishing;" mandates subsistence as a priority use; and establishes a "subsistence section" in the department of fish and game. The implementation of that law, which became effective on October 10, 1978, is proceeding. We are beginning to staff the new "subsistence section," and the boards of fisheries and game are in the process of soliciting proposals for subsistence regulations. At their forthcoming meetings and public hearings in late March and early April, 1979, they will adopt certain policies and general provisions and will promulgate regulations governing subsistence use of fish and wildlife—for such use by *all* Alaskans.

Other action being contemplated by the state at the present time is the regionalization of the "Regulatory Board System" to improve the public participation process in the setting of fish and game regulations. A bill is now under consideration by the state legislature for establishing six "Fish and Game Resource Regions" and six "Fish and Game Regional Councils," and reorganizing the present local advisory committee system into "Local Fish and Game Committees" within each of the regions. It is designed especially to increase the participation of local people in the regulatory system that governs their utilization of the fish and wildlife resources of the state.

Concluding Remarks

The above discussion summarizes briefly the "Native Claims" issue in Alaska, and the problems associated with the Alaska Native Claims Settlement Act of 1971. The problems—real and potential—of resource management in Alaska relate *not* to the claims and desires of our Native peoples, but rather to the heavy hand of environmentalists in the development of federal implementing law that will divide Alaska into various land-managing authorities—private, state and federal—and will impose severe constraints upon the use of both land and resources. Satisfying the subsistence needs of Natives and other rural residents as a priority use will cause some difficulty on the allocation of a few species, but at present and for the forseeable future the problem should be minimal. It is fortunate that Alaska has not had to deal with reservations and treaties as have the various other states and provinces. It remains to be seen, however, what future actions of the Congress and the courts will impose.

Federal, Provincial and State Government Perspectives

Some Aspects of the Native Harvest of Wildlife in Canada

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The title of this paper, "The Native Harvest of Wildlife in Canada," is one which I'm sure conjures up many different images among different people. To many, the Native harvest of wildlife is primarily an issue of human rights, those on one side of the issue regard special Native hunting rights to be an essential element of cultural heritage of Canada's Inuit, Indians and, perhaps, some Métis, while others feel that hunting rights (if they be rights at all and not merely privileges) should be the same for all citizens regardless of racial origin. And there are those who believe that the essence of the issue is a legal one, a rather tangled and confusing legal study to be sure, even among those who are intimately concerned with the unravelling. Inevitably, it has also transformed into an issue of politics on many levels. Lamentably, but also inevitably, to some, the Native harvest of wildlife is primarily sand in the wheels of a smooth running bureaucracy, an irritant which would be best appreciated by its absence.

In this paper, I propose to put these perspectives aside as much as possible and to concentrate on wildlife. Specifically, I want to examine what we know of the effect of Native kill on fish and wildlife populations. I approach the topic using migratory birds as my major examples because it is with this sector of wildlife management that I am most familiar.

Importance to Native People

At the last full census in 1971 there were approximately 300,000 status Indians and Inuit in Canada. In general, where special hunting rights apply for Native people, the beneficiaries are only those people which are defined as Indians or Inuit under the Indian Act. The size of the Métis and non-status Indian population is not well known, largely because there are no universally accepted criteria for distinguishing a Métis in the general population. Population estimates vary between 250,000 and 750,000 depending on definition. Some of these people view themselves as being elementally Native and follow a way of life similar to their Indian kin. Others do not choose to adopt this life style. The definition of who, and who is not, a Native person is one of the very difficult questions lying just below the surface when one considers the Native use of wildlife.

A corollary to the question of the existing or potential impact of Native harvesters on wildlife is the study of the importance of wildlife to Native people. Several studies have been done with primarily this objective.

Most recent harvest studies in northern Canada have been spurred by the prospect of land claim negotiations or by perceived threats to subsistence life-styles caused by resource development proposals. In August of 1973, the Federal Government recognized that a Native interest might exist on lands in Canada where this undefined interest has not been extinguished by treaty or superseded by law. The Government announced that one prerequisite for negotiation was the documentation of traditional Native usage and occupancy of the land. Money, in the form of grants and loans, was made available to Native groups who intended to enter into comprehensive land claims negotiations to enable them to research and develop their claims.

Two major land use and occupancy studies have been published as a result of this initiative, one looking at Inuit land use in the Northwest Territories (Milton Freeman Research Limited 1976) the second studying land use by the Inuit and Settlers of Labrador (Labrador Inuit Assoc. 1977). The purpose of these studies was to identify the areas used by Native people, both historically and at present, the types of wildlife used by the members of each region or community and the relative importance of each faunal component. By so doing, the importance of subsistence harvesting practices compared to other means of securing a living was implied, although rarely made explicit. No attempt was made to establish quantitative estimates of harvest and thus the information cannot be used directly to assess the impact of hunting and fishing practices on wildlife.

Funds have been provided for the preparation of several other land use and occupancy studies, notably in the Yukon and Mackenzie Valley, but these have yet to be published.

Several harvesting studies have been done in the Mackenzie Valley, however, under the joint impetus of land claims and the prospect of a natural gas pipeline. A report prepared as part of Environmental-Social Program by Stager (1974) provides one of a few examples in Canada of a study which apparently generated accurate, quantitative estimates of the use of all types of fish and wildlife by a community. He studied the hunting and fishing practices of people of Old Crow in the Yukon.

Studies in the Mackenzie Valley (Bissett 1974, Usher 1975, 1977, Gemini North Ltd. 1974) suffered from the lack of a quantitative data base which was verifiably accurate. For a variety of reasons, researchers were forced to depend heavily on data which had previously accumulated through a number of sources. Records of commercial fish harvest are fairly complete and accurate in the Northwest Territories and estimates of domestic and commercial fish catches, especially in the Mackenzie Delta, are better than is the case for most other species. The difficulties encountered in interpretation of the data base, especially those relating to land mammals and birds, are summarized by Berger (1977: 8). Despite difficulties with the data, Berger concluded that hunting, fishing and trapping could and do form the basis of a viable renewable resource economy in the Mackenzie Valley. The conclusion has not met with universal approbation (e.g. Stabler 1977) largely because of the fact that "there exists no systems for regular collection of data that can provide simple, accurate indications of the numbers of people participating in the traditional sector of the economy, or of the volume or value of their produce" (Berger 1977: 9).

Throughout the Franklin and Keewatin Districts, many harvest studies are underway or have been recently completed, largely as a result of proposed and existing petroleum development. Most are sponsored by the proponent (e.g. Polar Gas Ltd., Petro Canada, Imperial Oil Ltd.) and are orchestrated by environmental consultants. Those studies which rely on existing data bases, such as year-end reports by General Hunting License holders in the NWT and on brief community visits (e.g. McLaren Atlantic Ltd. 1978) suffer in credibility for the same reasons as do the Mackenzie Valley studies. The data base on which they depend is of very uneven reliability. Other studies which rely more heavily on acquiring new harvest data from Native people over an extended period of time, such as those presently underway in Pond Inlet and Grise Fiord and those proposed for other Baffin communities, show more promise of generating reliable quantitative data.

The most comprehensive survey of wildlife harvest by Native people in Canada to date, has been undertaken in northern Quebec as a result of land claim settlements in that region. The studies provide relatively reliable quantitative estimates of harvest by species or species group and show that the Cree and Inuit people of northern Quebec are highly dependent on the land and its resources (NHRC 1976 a, 1976 b, 1978). These data can be very useful to people concerned with wildlife management, both within governments and among the Native people themselves. Some of these applications will be examined later in this paper.

From these and many other studies, it is now apparent that in most northern communities, especially those which are relatively isolated from the "mainstream" of society, subsistance harvesting is an essential element of the regional economy and cultural identification. In southern Canada, hunting and fishing may still be pursued, but more rarely is it a cornerstone to the regional economy. There are exceptions, for example, in British Columbia where many Native groups still depend heavily on aquatic resources for food.

It is difficult and perhaps perilous to generalize about trends in Native use of wildlife. In the Northwest Territories there are opposing pressures of wage employment and development on the one hand and an increasing interest in returning to the traditional lifestyles by young people on the other. The strength of the latter can be seen to some extent in the success of NWT outpost camp programs.

The effect of regular contact with the outside world is typefied by the situation in northern Ontario. As late as the 1950s, essentially all of the Indian people north of the Canadian National Railway tracks were primarily dependent upon hunting and fishing for their livelihood. (See Ontario Ministry of Natural Resources, District Reports, 1950s). Today the character of many communities has changed dramatically as ground and air transportation has improved access. Communities to which roads have been built have shown the most dramatic decreases in economic dependence on wildlife resources (McIlveen, personal communication). Similar pressures of the dominant social structure have apparently had equal impact in the Stony Rapids Region of northern Saskatchewan, where after extensive study, Bone and coworkers (1973:79) concluded that as an economic base, bush life was finished, which implied an end to the old style of trapping and living off the land. In northern Manitoba, however, the 1970s saw the rebirth of a Chipewyan community at Tudule Lake made up of Indian people who had faced a cul-de-sac in Churchill. There, 200–300 people have re-established fish and wildlife harvest as the foundation of their economy and in so doing have rediscovered their self-respect.

To generalize about trends in wildlife usage is therefore a dangerous proposition. Each community and region must be viewed separately. Even accepting this caveat, trend analysis may be complicated by a lack of quantifiable data and by people's perceptions of harvest intensity which may depart substantially from true levels.

Impact on Wildlife

As I indicated in my opening remarks, the subject of Native harvest of wildlife is entangled in issues of human rights, law, politics and bureaucratic formulae. Not uncommonly, arguments from both sides have strong suggestions of racial prejudice. For a variety of reasons, these considerations must ultimately be put aside and the preservation of existing fish and wildlife populations at a relatively high and reasonable level must become a priority. In the extreme, it would indeed be criminal to blinker ourselves with arguments of human rights, law or politics and by so doing see another wildlife population decline to extinction or near extinction.

Native people, through their hunting, fishing and trapping activities, can as surely adversely affect the prey population as can any other harvester of the resource. Many Native people believe that they are conservationists by nature and cannot over harvest the resource. This point of view is often understandable since prior to the advent of modern means of transportation and modern weapons, this perceived lack of capability to eradicate a wildlife population was usually a reality. Today this is often not the case. As Seiber (1978) notes, adoption of the premise that Native people are necessarily in balance with their ecosystem is perhaps a good way to win friends among Native people, but it is demonstrably wrong and may ultimately be dangerous to the wildlife populations on which they depend. Many Native hunters are expert and responsive to the welfare of the populations on which they depend. Unfortunately, as with other hunters, some are not as skilled or responsible. In other cases, especially for migratory species and those with highly contagious distributions, it may be difficult for the hunter to easily detect population changes and therefore react to these in an appropriate manner. Given these facts, it is appropriate to assume in the first instance that a Native is little more or less a natural conservationist than is any other hunter. On the other hand, because Native people in some communities have a vested interest in the welfare of wildlife populations, they are often very concerned about conservation issues.

It is technically more difficult to determine the impact of Native people on wildlife populations than to determine the relative economic importance of subsistance harvest to a Native community. As for any other wildlife management exercise, one must define the wildlife population(s) affected, determine essential elements of the population dynamics (i.e. birth rate, natural mortality, recruitment and other biological factors) and learn who is harvesting from the population and to what extent.

Typically, biologists never know enough about the wildlife populations which they are studying. "More research" threatens to become our war cry. Nonetheless, our ignorance of Native harvest of wildlife in quantitative terms is manifest.

Some studies which have been done were referenced earlier. In many cases, the lack of quantitative data is not material, especially in southern Canada, where in most cases the wildlife which Native people use are not substantially affected by their exploitation. Native people using a wildlife or fisheries resource are often heavily outnumbered by sports hunters and occasionally draw from the same stocks as do commercial harvesters. Usher, Hunter, and Friesen and Nelson (1978) in separate papers, all emphasized that in the Northwest Territories where Native people often exclusively use a wildlife population, there is often potential for an increased harvest. They referred specifically to some fur-bearing species. As will be pointed out in a later example, this is not always the case.

Regarding the impact of Native take of wildlife in broad geographic terms or without consideration for individual populations, can be misleading. The implications of this error can best be illustrated by example.

In the early 1970s Neave (1972) reported that 19,000 moose were taken by 53,000 sports hunters versus 8,000 by 29,000 treaty Indians. He concluded that this harvest, together with that taken by poachers, amounted to light harvest overall for moose in Alberta. In the foothills, however, the kill of 10,000 animals, of which 40 percent was by Indian people, was thought to exceed annual recruitment of 30 percent and the regional population was in decline. Native kill was obviously contributing to overharvest.

In British Columbia, those of the resident 55,000 Indians who are still dependent to some degree on country food, rely largely on salmon and other aquatic resources. Regarded in the aggregate, their take of salmon relative to commercial and sport harvest is small. Between 1972 and 1976, commercial fishermen in British Columbia averaged 22 million salmon per year. During the same period, sport fishermen caught in the order of 1 million salmon, while Native food fishermen took 0.5 million per year. Native fishing thus accounted for approximately 2 percent of the provincial harvest and their impact on this resource would, on quick examination, appear to be minimal.

Nonetheless on occasion, a specific stock of salmon is threatened by Native food fisheries. The coastal bands tend to have little impact on specific stocks because they have access to different stocks of fish at various times of the year as they pass along the coast. The inland fishermen have to concentrate their catch during the spawning run. In rivers with large runs, such as the Adams, the relatively small Indian take can have little impact on the stocks. However, in creeks with small runs, the impact of Native fishing can be hazardous. For example, in 1978, Indian people took approximately 50 percent of the entire Early Stuart Stock of sockeyes from the Fraser. The remaining population of 57,000 salmon was 50,000 below the safe minimum population size as estimated by fishery biologists.

An example of regional over-exploitation of an ungulate population by hunters is that of the Kaminuriak caribou herd which ranges throughout the southern portion of the Keewatin and traditionally wintered in parts of northern Manitoba and Saskatchewan. The case has been fully discussed by Norm Simmons of the Northwest Territories Fish and Wildlife Service in an earlier session of this conference. The Kaminuriak herd is demonstrably declining and now numbers slightly in excess of 40,000 individuals. In the 1950s, it was thought to number close to 150,000. The range is contracting and animals no longer regularly migrate into areas which they routinely frequented for portions of the year. Native people are the major hunters of this population and their take is known to exceed 3,000 animals per year, although as is often the case, exact figures are lacking. Caribou biologists concerned with management of this resource have concluded that a take of 2,000 animals represents the maximum value if the herd is to maintain a stable population. Clearly, the level of harvest must be reduced or the herd may disappear and the Inuit and Indians dependent upon it may face unnecessary hardship.

The Case of Migratory Birds

The Native use of migratory birds present a rather different problem because in most cases the bird populations on which they are dependent are also drawn upon by hunters in Canada, the United States and, more rarely, Mexico. Waterfowl represent the most important group of migratory birds to Natives as well as non-Native hunters in North America. Until fairly recently, waterfowl managers have largely ignored Native kill in their rough equations which attempt to balance production versus mortality. Perhaps the major reason for this is that reliable quantitative information concerning the Native harvest of waterfowl is only rarely available. The communities in which studies have been made are all in northern Canada. In most cases the per capita use of waterfowl in a year is extremely high; e.g. 48.0 waterfowl per person in Habay in 1966, (McCauley and Boag 1974); an average of 25.1 waterfowl per person among the Cree in northern Quebec in 1973–74 and 1974–75 (NHRC 1976a) and; 10.4 waterfowl per person in Tuktoyaktuk in 1966 (Barry 1973). An exception is in Old Crow where the use of waterfowl was reportedly quite light (Stager 1974). The high reported per capita use reflects that researchers have generally chosen to look at communities where waterfowl use was known or thought to be high. It is important to note, therefore, that the reports in the literature do not present results which can be taken as representative of Canadian Native population as a whole. Extrapolation from existing studies would provide completely misleading results. A more representative data base is needed. It should also be noted that some of these studies are now more than 10 years old and the results may not accurately reflect the present situation.

One of the major reasons that data on the Native kill of migratory birds is not more generally available is that much of their hunting, especially in northern Canada, has been out of season and this has generally made government biologists cautious about examining the extent and pattern of harvest and Native people generally reticent about providing information about their hunting success, which could be incriminatory. If the recent amendment to the Migratory Birds Convention is given effect in law, we will have more flexibility in establishing fair and reasonable regulations for the hunting of waterfowl by Canada's Indians and Inuit. If this occurs, then it should be easier to accumulate harvest statistics, on the one hand, and more necessary to have these data, on the other, so that special regulations for a spring and summer hunt can be assured of protecting waterfowl populations and be seen to be fair by both Native and non-Native hunters.

A second major reason for the limited availability of harvest statistics on waterfowl is that only recently have waterfowl managers come to appreciate the fact that Native kill may not represent a negligible proportion of the Canadian or North American harvest of some waterfowl stocks. Recent estimates of Native kill in Canada have been made by the Canadian Wildlife Service based on extrapolation from that data which exist and the best estimates of a number of our biologists (Table 1). These estimates include multiplying factors to allow for crippling loss and illegal kill. Native hunters take an estimated 10.8 percent of the approximately 6.5 million ducks harvested in Canada in an average year. Their share of the North American harvest is only 2.6 percent. Their take of geese is proportionally much higher; 31.1 percent of the Canadian kill and 11.1 percent of the North American harvest. Among duck species, which are grouped by tribes, the proportional take by Native hunters varies dramatically. Among the puddle ducks, which are by far the most heavily hunted group, their take is only 8.5 percent of Canadian kill and a mere 1.8 percent of North American harvest.

The impact of Native hunting on waterfowl populations cannot be fully appreciated without looking at individual populations.

Boyd (1977) used harvest statistics obtained by the James Bay Northern Québec Harvesting Research Committee (NHRC 1976a, 1978) to compute the relative importance of Cree and Inuit kill from this region on several goose populations. Approximately 1,500 Native hunters took 78,000 Canada Geese, 31,000 Lesser Snow Geese and 8,500 Brant Geese per year during the period 1973 to 1975. The total harvest of approximately 117,000 geese per year illustrates the very great importance of these species to the welfare of these people. During the same period, the Crees took an estimated 54,000 ducks per year (NHRC 1976a), while the Inuit took approximately 15,000 ducks in 1975 (NHRC 1976b). The Inuit also took a large number of eider eggs but present estimates are considered to be unreliable. Among the seven Cree communities in the region, waterfowl accounted for between 6.2 percent and 47.4 percent by weight of the wildlife food taken by these people who are predominantly subsistence users. The average was 31.6 percent, the variation among communities being largely due to the availability of waterfowl relative to other fish and wildlife species (NHRC 1978).

Boyd (1977) calculated that the Native kill in northern Québec represented 12.9

Table 1. Relative impact of Native Canadian hunters on waterfowl populations (numbers in thousands).

Ducks Tribe	Average September populations	Canadian harvest: Native	Canadian harvest: Other sources	USA	% Native of total Can. kill	% Native of N. Amer. kill	% Native kill of total pop. size
Anatini & Cairinini	43,572	403	4,418	17,645	8.5	1.8	0.9
Aythyini	7,483	35	590	1,988	5.6	1.3	0.5
Somateriini	3,165	141	147	30	49.3	44.3	4.4
Mergini & Oxyurini	7,342	125	638	706	16.4	8.5	1.7
Total ducks	61,562	704	5,793	20,369	10.8	2.6	1.1
Geese (Anserinae)	9,011	325	721	2,923	31.1	11.1	3.6

percent of the total North American kill of the three populations of Canada Geese which are available to them at various times of the year (Mid-Atlantic, Mississippi Valley and Tennessee Valley). Their impact on the Mid-Atlantic population was the most dramatic in that they accounted for 17.4 percent of the total. In addition, their harvest of Lesser Snow Geese represented 6.4 percent of the total harvest of the Eastern Arctic Snow Goose population (Hudson Bay and Baffin Island colonies).

In his paper, Boyd also ventured that other Native people in Canada took an additional 14,600 Canada Geese and 41,200 Snow Geese from these same populations. Recent studies of the Cree harvest on the Ontario side of James and Hudson Bays by J. P. Prevett and H. G. Lumsden (in preparation) suggest that Boyd's estimate may be somewhat conservative. In three years of study, 1975 to 1977, the kill of Snow Geese in 7 coastal communities varied between 30,000 and 50,000, the kill being much higher when the stop-over in the region during spring migration is longer than usual. For the same period, the kill of large Canada Geese (mainly *B.c. interior*) varied between 17,800 and 24,500 which would be drawn largely from the same populations as those harvested in northern Québec.

Taking notice of the fact that Boyd's estimates might be somewhat low (the extent of the underestimate being mostly dependent upon the amount of the harvest of these geese populations by Native people south of James Bay, which is quite unknown), it is interesting to note that according to his data, Native people account for an estimated 57 percent of the total Canadian harvest of Canada Geese from the Mid-Atlantic, Mississippi and Tennessee Valley populations (15 percent of the North American harvest). From the Eastern Arctic Snow Geese population, Native people account for 62 percent of the Canadian kill (15 percent of North American).

The impact of the Native hunter relative to the sport hunter varies widely among migratory bird populations and in relatively few cases is their impact as dramatic. The interest in the above examples rests in the fact that these geese populations are highly valued stocks to North American sports hunters and a great deal of effort and money have been spent on their management. Clearly, in this case, the interests of the Native hunters and their importance to the maintenance of these populations must be acknowledged and incorporated into future management initiatives. Equally on the part of Native people there must be an appreciation of the fact that other North Americans share an interest in the bird populations which they harvest. This interest exists among sport hunters and increasingly among other citizens who are interested in conservation of wildlife resources. Native people must also realize that through their use of wildlife, they can contribute to wildlife population declines.

Conclusions

From the game manager's viewpoint the most promising way to improve his management capabilities of species hunted by Native people is to incorporate the Native hunter into the game management process. This necessitates not only the enhancement of dialogue but also the assumption of some responsibility and authority for some management by Native people. The Native perspective is often that their needs and aspirations are not understood by government and they also seek increased dialogue and responsibility in game management.

Some mechanisms already exist in Canada which insures that this interaction takes place. The Hunting, Fishing and Trapping Co-ordinating Committee which was established under the terms of the James Bay Agreement is an example of a joint Native–industry–government group which has considerable responsibilities for wildlife management. Similar arrangements are envisioned in the Agreement in Principle signed by the Inuit of the western Arctic and the Federal Government and are sure to be an important element in any future land claim settlements.

In all of these cases, it is important that governments retain the ultimate authority to regulate with respect to game management issues if necessary because it is governments which are ultimately accountable for welfare of wildlife populations. Given this caveat, however, there still exists considerable opportunity to delegate responsibility and improve dialogue. It is the responsibility of government managers to ensure that Native hunters are well informed about game management issues and the role of Native people to meet these issues with responsible actions.

A second conclusion which arises from this paper is that our knowledge of fish and wildlife harvest is generally insufficient. The acquisition of these data is a necessary first step for the proper management of game species on which Native people depend. This can only be done with the full cooperation of Native hunters. If the improved dialogue envisioned above can be attained, the acquisition of better harvest statistics should be a first priority.

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Federal, Provincial and State Government Perspectives

A Legal Perspective on Natives and Wildlife in Canada

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Introduction

Post-war Canada has been characterized by urbanization, industrialization and population growth. These developments have affected both the size and quality of wildlife habitat. Simultaneously, the stresses of modern life have created new interest in outdoor recreation, including hunting and fishing.

Over the past decade a third trend has exacerbated the conflicting demands on wildlife. The Native people of Canada, many of whom rely upon hunting, fishing and trapping for both sustenance and livelihood, have demanded greater guarantees concerning their use of wildlife. They have also demanded participation in and/or control over wildlife management decision making. This trend reflects their recognition, in some cases, of the forces which threaten the viability of certain species; in other cases, cultural self-identity dictates that their option to pursue a traditional lifestyle be kept open.

In the past few years these developments have led to open conflict in many parts of Canada, involving government regulators, Native groups, and non-Native fish and game associations. At the same time, land claim settlements in frontier areas have attempted to finesse future conflicts through new legislative and institutional mechanisms.

This paper assesses the Native/wildlife relationship in Canada from a legal perspective. It is divided into three parts. The first deals with the current legislation and case law which defines Native hunting and fishing rights. The second part examines the recent use of by-law making powers by Indian bands to manage and regulate wildlife on Indian reserves, and the treatment of Native hunting and fishing rights under land settlements in northern Quebec and the Mackenzie Delta. The final part sketches possible approaches for the future.

The Legal Basis for Native Rights

The legal foundations for Native claims to special wildlife harvest and management rights in Canada vary widely. The rights of a particular Native group depend upon geographical, historical, legislative and judicial factors. Because of these divergent influences, Native rights are generally ill-defined in law, differ from place to place, and probably have little or no rational basis from the point of view of wildlife management.

The following section summarizes existing Canadian law. The discussion is organized around the sources from which special Native rights emanate. The reader is cautioned that there are variations at a provincial and/or regional level in the laws described, depending upon legislation, the wording of treaties, and historical factors.

Constitutional and Treaty Guarantees, and the Indian Act

Legislative jurisdiction over "Indians, and Lands reserved for the Indians" is expressly granted to the federal government under s.91(24) of the *British North America Act.*[1] The term "Indians" under s.91(24) has been held to include Inuit,[2] while "Indian lands" has been judicially construed as broader than merely Indian reserves.[3] As will be seen, the special constitutional treatment of Canadian Indians and Inuit does not necessarily foreclose the exercise of provincial legislative competence in relation to such groups. Nevertheless, it has introduced complexities and ambiguities which are not yet fully resolved, many of which are pertinent to wildlife management issues.

In approximately half of Canada, Indian harvest rights flow in part from treaties entered into between the 1800s and the early 1900s. Under these documents, Indian rights to vast areas of land were surrendered in return for small monetary payments, the retention of some lands, and a variety of other promises. The background to and content of the treaties is far from uniform, but most contain clauses relating to the use of wildlife. The legal effect of such guarantees is discussed below. The following clause from Treaty No. 3, entered into with the Indians of southwestern Ontario in 1873, is an example of one harvest guarantee:[4]

> Her Majesty further agrees with Her said Indians that they, the said Indians, shall have right to pursue their avocations of hunting and fishing throughout the tract surrendered as hereinbefore described, subject to such regulations as may from time to time be made by Her Government of Her Dominion of Canada, and saving and excepting such tracts as may, from time to time, be required or taken up for settlement, mining, lumbering or other purposes by Her said Government of the Dominion of Canada, or by any of the subjects thereof duly authorized therefor by the said Government.

In the three prairie provinces, Indian harvest rights are also affected by the terms under which natural resource ownership was transferred to the provincial governments in 1930. The Natural Resources Transfer Agreements in Manitoba, Saskatchewan, and Alberta all contain the following clause:[5]

> In order to secure to the Indians of the Province the continuance of the supply of game and fish for their support and subsistence, Canada agrees that the laws respecting game in force in the Province from time to time shall apply to the Indians within the boundaries thereof, provided, however, that the said Indians shall have the rights, which the Province hereby assures to them, of hunting, trapping and fishing game and fish for food at all seasons of the year on all unoccupied Crown lands and on any other lands to which the said Indians may have a right of access.

[1]R.S.C. 1970, Appendices, at p. 191.
[2]*Re Eskimos*, [1939] S.C.R. 104.
[3]*St. Catherine's Milling and Lumber Co.* v. *The Queen* (1889), 14 A.C. 46 at 59.
[4]Reprinted as Appendix III in P. A. Cumming and N. H. Mickenberg, eds., *Native Rights in Canada*, 2nd ed. (Toronto: The Indian Eskimo Association of Canada, 1972) at p. 295.
[5]R.S.C. 1970, Appendices, at p. 371, 380–1 and 388–9.

Rights also flow in part from the federal *Indian Act.*[6] However, it should be noted that this legislation does not affect the same group of native persons as s.91(24) of the *British North America Act.* Section 4(1) of the *Indian Act* specifically excludes Inuit from its coverage. Nor does the existence or nonexistence of treaty rights alone govern the applicability of the *Indian Act* to a particular person or group. Instead, the provisions of the *Act* apply only to those natives specifically included within the definition of "Indian" in s.2(1). Under s.11, this may include (but is not restricted to) those members of an Indian band for whose benefit land has been set aside.[7]

Certain sections of the *Indian Act* are pertinent to the harvest rights of those native persons to whom the Act applies. Of importance to the current discussion is s.88, which provides:

> Subject to the terms of any treaty and any other Act of the Parliament of Canada, all laws of general application from time to time in force in any province are applicable to and in respect of Indians in the province, except to the extent that such laws are inconsistent with the Act or any order, rule, regulation or by-law made thereunder, and except to the extent that such laws make provision for any matter for which provision is made by or under this Act.

Much judicial energy in this country has been expended in examining the interplay between the above provisions, and in defining the parameters of resulting native harvest rights. Since it is generally accepted that provincial governments have jurisdiction to legislate in regard to wildlife[8] (with the exception of fisheries), much of the controversy has centered upon the extent to which provincial laws may determine or impede native rights.

It is well-settled law that Parliament may validly override Indian treaty rights through legislation. This issue has been decided in the context of the *Migratory Birds Convention Act*[9] and the *Fisheries Act*,[10] and also in relation to federally-owned lands such as National Parks.[11] From a purely legal point of view, this has rendered treaty promises meaningless, at least to the extent that federal legislators decide to ignore them. From a wildlife manager's point of view, it means that there exists legislative power to control certain types of native harvest.

Because of provincial legislative jurisdiction over wildlife, a more important but vexing issue has been the extent to which provincial laws may regulate native harvest. It is clear that provincial laws cannot infringe rights guaranteed by treaty. In the 1965 decision of *Regina* v. *White and Bob*,[12] the Supreme Court of Canada acquitted two British Columbia Indians charged under the B.C. *Game Act* with having six deer carcasses in their possession out of season, holding that their

[6]R.S.C. 1970, c.I-6.

[7]A detailed discussion of the various classifications of native persons under Canadian law can be found in *Native Rights in Canada, supra* n.4 at 6 *et.seq.*

[8]*R.* v. *Robertson* (1886), 3 Man.R. 613.

[9]*Sikyea* v. *The Queen,* [1964] S.C.R. 642, (1965), 44 C.R. 266.

[10]*R.* . v*Derrikson* (1976), 71 D.L.R. (3d) 159 (S.C.C.).

[11]*R.* v. *Rider* (1968), 70 D.L.R. (2d) 77 (Alta.Mag.Ct.) This decision turned upon an interpretation of a clause in a particular treaty, and the finding that federal parks legislation did not contravene the clause. The judge held, however, that even if the treaty had been violated, the federal government was competent to do so.

[12](1965), 50 D.L.R. (2d) 613 (S.C.C.).

treaty-guaranteed right to hunt on unoccupied lands must prevail over provincial law.

To baldly state that provincial legislation cannot encroach upon treaty rights, however, is to mask many deeper issues arising from s.88 of the *Indian Act* and, on the prairies, from the Natural Resources Transfer Agreements.

It will be recalled that under the latter agreements the provinces undertook to honor Indian hunting rights upon certain lands. The scope of this guarantee has been the object of considerable judicial scrutiny. In some cases, it has been narrowly construed. For example, in a recent Alberta case[13] it was held that the provisions of Treaty 7 did not prevent provincial prohibitions against hunting in a wildlife sanctuary from applying to Indians. Since the decision turned upon the holding that a wildlife sanctuary was "occupied" land, it has enormous ramifications for the future protection of Indian rights from provincial law. Provided that the land is "unoccupied" or lands to which Indians have a right of access, the Agreements have been held to extend special rights to Indians from another province,[14] and to authorize Indians to shoot deer with antlers less than the length permitted by provincial law[15] and to hunt at night with lights despite a provincial law to the contrary.[16] But the protection only extends to hunting "for food." Thus, in *Cardinal* v. *Attorney General of Alberta*,[17] a treaty Indian was convicted of selling a piece of moose meat to a non-Indian on a reserve, contrary to provincial law. So even on reserves provincial wildlife laws may apply to Indians in certain cases.

But the precise scope of and rationale for the applicability of provincial laws to Indians remains in some doubt. The issue turns in part upon the interpretation of s.88 of the *Indian Act*. It has been held that so long as provincial laws are not specifically directed at Indians, but rather are laws of general application, they will apply to Indians.[18] As a result, B.C. game laws have been applied to non-treaty hunting without a permit during a closed season.

To summarize, under current law those Indians in Canada who benefit from hunting rights guarantees in treaties are protected from provincial (but not federal) laws which encroach upon the treaty promises. On the prairies, the exemption from provincial law is limited to hunting for food upon certain types of lands. It appears that general provincial game laws apply to non-treaty Indians by virtue of s.88 of the *Indian Act*, and that such laws may apply to Indian reserves provided they do not conflict with treaties.

Rights Arising from Specific Legislation

It should be noted in passing that special rights relating to harvest are granted to Native groups under various provincial and federal laws. For example, s.14(3) of the *Northwest Territories Act*[19] prohibits the Northwest Territories Council from

[13] *R.* v. *Kootenay, Youngman & Youngman*, an unreported decision of Prov. Judge G. G. Cioni, April 27, 1978.
[14] *Frank* v. *The Queen* (1977), 75 D.L.R. (3d) 481 (S.C.C.).
[15] *R.* v. *Wesley*, [1932] 4 D.L.R. 774, 2 W.W.R. 337 (Alta. App. Div.).
[16] *R.* v. *Prince* [1964] S.C.R. 81.
[17] [1974] S.C.R. 695.
[18] *R.* v. *Kruger and Manuel* (1977), 75 D.L.R. (3d) 434 (S.C.C.)
[19] R.S.C. 1970, c.N-22.

passing legislation which would interfere with the right of Natives to hunt nonendangered species for food upon unoccupied Crown land. Special rights are granted to Natives under certain regulations passed pursuant to the federal *Fisheries Act*.[20] The *National Parks Act* allows harvesting activities to be pursued by native peoples in park reserves north of 60°.[21]

Because these rights flow from legislation, they can also be taken away by legislation. In the case of federal or provincial statute, an amendment could be passed by Parliament or the provincial legislature. In the case of regulations, a new Order-in-Council could be passed by the Cabinet. Since this type of right is not entrenched constitutionally or otherwise, it is only as secure as the legislative will to protect it.

It is worth mentioning that, until recently, Natives could also receive special treatment concerning wildlife simply by a policy of nonenforcement. This commonly occurred in Canada in relation to offenses under the *Migratory Birds Convention Act*. As a result of a recent decision, this avenue has been closed. In *R.* v. *Catagas*,[22] an Indian charged with unlawful possession of migratory birds defended himself on the basis of a government document which stated that Natives would not be prosecuted for taking birds for food. The Manitoba Court of Appeal held that, although the Crown always has prosecutorial discretion not to proceed in an individual case, it has no right to dispense with the application of a statute in favor of a particular group or race. Thus, any future attempts to exempt Native people as a group from the operation of a law, at the enforcement level, will be illegal.

Rights Based Upon Aboriginal Land Claims

As mentioned earlier, in nearly half of Canada, no land cession treaties have been entered into with Natives. In such areas (including most of British Columbia and northern Canada) special harvest rights may be claimed by Natives on the basis of aboriginal land title. According to this theory, harvest rights accrue to the Natives as a result of their land ownership.

This basis for Native claims to wildlife has never been fully resolved by the Canadian courts.[23] In *R.* v. *Derrikson*,[24] rights based upon aboriginal title were pleaded in defense to an infringement of federal fisheries regulation. Without expressing an opinion on the subject, the Supreme Court of Canada held that even if such a right did exist, it could be overridden by federal legislation. The point was also raised in *Kruger & Manuel* v. *The Queen*,[25] this time in defense to a charge under British Columbia game laws. Again, the Supreme Court of Canada declined to comment on the issue, instead basing its decision upon s.88 of the *Indian Act*.

As a result, further definition of Native harvest rights on this basis must await future litigation.

[20]For example, s.6(2) of the Narwhal Protection Regulations, S.O.R..77–516 authorizes special tagging arrangements for Inuit hunters.
[21]S.C. 1974, c.11, s.11(1).
[22](1978), 81 D.L.R. (3d) 396 (Man.C.A.).
[23]Furthermore, many issues relating to the title aspect of aboriginal claims remain unresolved. The most definitive judicial statement on the subject remains *Calder* v. *Attorney General of British Columbia* [1973] S.C.R. 313.
[24](1976), 71 D.L.R. (3d) 159 (S.C.C.).
[25](1977), 75 D.L.R. (3d) 434 (S.C.C.)

Recent Developments Resulting from Indian By-laws and Land Settlements

The preceding analysis has emphasized the legal basis for Native harvest rights as it has evolved historically, constitutionally, legislatively, and judicially. The results have not been entirely satisfactory. Indians have argued persuasively that their treaty rights have been subject to encroachment by federal law, and that court decisions have narrowed the scope of such rights provincially. Non-treaty Natives have, in some respects, been even worse off. In the absence of special legislative provisions, Canadian law has provided them little by way of harvest rights.

On the other hand, some wildlife managers have considered their hands tied by laws guaranteeing special rights to Natives. Moreover, certain non-Native hunting and fishing associations have been concerned that lack of Native harvesting regulation would damage wildlife stocks and/or reduce the availability of wildlife for their own recreational pursuits.

The following section examines efforts over the past few years to resolve these conflicts through new initiatives.

Band By-laws Under the Indian Act

Rules and regulations concerning wildlife on Indian reserves may originate in two ways. First, section 73(1) (a) authorizes the Governor in Council (the federal cabinet) to make regulations "for the protection and preservation of fur-bearing animals, fish and other game on reserves." Second, s.81 (o) authorizes a Band Council to make by-laws not inconsistent with the Act or any federal regulations for the purpose of "the preservation, protection and management of fur-bearing animals, fish and other game on the reserve." Section 82 requires a copy of any by-law to be mailed to the Minister within 4 days of being made. The by-law comes into force 40 days after it is mailed to the Minister, unless he disallows it within that period or sooner declares it to be in force.

Regulations or by-laws regarding wildlife passed pursuant to either of these sections could apparently foreclose the applicability of provincial game laws to a particular reserve, since under s.88 provincial laws of general application apply to Indians only to the extent that such laws are not inconsistent with the Act or any by-law made thereunder. Moreover, while the point has not been judicially tested, it would also appear that such a regulation or by-law would override any similar regulation passed pursuant to other federal legislation, such as the *Fisheries Act*. The reason for paramountcy of the *Indian Act* regulation or by-law relates to the fact that its subject matter is specifically authorized, while the *Fisheries Act* is in general terms.

The regulation-making power of the federal cabinet under s.73(1) (a) does not appear to have been exercised at the present time. In the past, certain bands exercised their authority under s.81(o) by passing by-laws relating to non-Indian hunting on the reserve.[26] More recently, and in the face of conflicts with fisheries officers, at least two Indian bands have attempted to exercise the s.81(o) power. In one case, that of Kingsclear band in New Brunswick, the proposed by-law was disallowed by the Minister for the technical reasons relating to uncertainty as to

[26]Discussed in D. Saunders, "Indian Hunting and Fishing Rights", (1974) 38 Sask.L.Rev. 45 at note 31.

the area where it would apply.[27] Instead, an interim agreement between the fisheries officers and the Indians was reached, featuring Indian participation in management of the resource.

In the second case, that of the Squamish Band in North Vancouver, the by-law came into effect in November 1977.[28] It applies to all waters on the Squamish Reserve, and prohibits the fishing thereon by anyone other than a member of the Band. It authorizes the Band Council to appoint fisheries officers to enforce the by-law, as well as a Band Manager who is given regulation-making power for the purpose of carrying out the by-law. Certain detrimental activities are prohibited, including the destruction of fish eggs or fry on spawning grounds, the deposit of debris and other deleterious substances into water frequented by fish, and fishing for salmon fry, parr and smelt. Band members are authorized to engage in fishing in reserve waters at any time and by any means except rockets, explosive materials, projectiles or shells.

The Squamish by-law may exemplify directions for the future, with Indians increasingly managing the wildlife resources on their own lands. Some concern has been expressed that this kind of development will lead to destruction of resources. This issue will be addressed in the final section of the paper.

The James Bay and Northern Quebec Agreement

Signed in 1975 between the Inuit and Cree Indians of Northern Quebec, the Quebec and Canadian governments, and corporations involved in a hydro-electric project on James Bay, this Agreement ended litigation launched by the Natives, and was the first modern negotiated settlement of a Native land claim in Canada.[29]

The Agreement is extremely complex, covering more than four hundred pages. It divides northern Quebec into three areas, called Categories I, II and III. The Natives own surface rights on Category I lands, which cover a tiny portion of the Territory. They are given broad harvest and other rights on Category II lands. The balance (and largest part) of the Territory is called Category III.[30] Section 24 of the Agreement, entitled "Hunting, Fishing and Trapping", will be the focus of attention here.

Two basic themes underlay this part of the Agreement. One is that Native people ought to be guaranteed special harvest rights. The other is that they should participate in decisions about wildlife management and use. It is important to note that the Hunting, Fishing and Trapping Regime established by the Agreement is subject to the principle of conservation, defined in s.24.1.5:

> "Conservation" means the pursuit of the optimum natural productivity of all living resources and the protection of the ecological systems of the Territory so as to protect endangered species and to ensure primarily the continuance of the traditional pursuits

[27]Letter from Pat Wilson, Special Assistant to Minister of Indian and Northern Affairs (n.d.).
[28]S.O.R. 77–883.
[29]*The James Bay and Northern Quebec Agreement* (Quebec: Editeur officiel du Quebec, 1976).
[30]The area covered by the Agreement is some 410,000 square miles. Cree Category I lands are 2,158 square miles, and Inuit Category I lands are 3,250 square miles. In Category II, Cree lands cover 24,899 square miles, and Inuit 35,000 square miles.

of the Native people, and secondarily the satisfaction of the needs of non-Native people for sport hunting and fishing.

Section 24.3.2. grants Native persons the right to harvest wild fauna except where the continued existence of a particular species is threatened. "Harvesting" is defined in s.24.1.13:

> "Harvesting" means hunting, fishing and trapping by the Native people for the purpose of the capture or killing of individuals of any species of wild fauna, except species from time to time completely protected to ensure the continued existence of that species or a population thereof, for personal and community purposes or for commercial purposes related to the fur trade and commercial fisheries.

Harvest rights may be exercised where it is physically possible to do so, and where not in conflict with other rights or with public safety. (s.24.3.4) The creation or existence of parks, wilderness areas and the like will not preclude the exercise of harvest rights therein, but the creation of wildlife sanctuaries will. (s.24.3.6) Generally, permits and licences will not be required; (s.24.3.18) moreover, the principle that Natives shall be subject to a minimum of regulation is stressed. (s.24.3.30)

The Agreement grants Natives the exclusive right to trap throughout the Territory. (s.24.3.19) On Categories I and II lands, they exclusively may operate commercial fisheries; on Category III lands they are granted exclusive rights to particular species, including polar bear, mustelids, muskrat and foxes. (s.24.7.1, Schedule 2)

Section 24.3.8 generally protects the present rights of outfitters and lease and permit-holders. Non-Natives are allowed to hunt and fish on Category III lands for sport, and subject to laws of general application. (s.24.8.1) In certain cases, allocations as between Native and sport hunters will be made by the Coordinating Committee, discussed below. But these provisions are generally subject to the concept of priority of Native harvest: to the degree permitted by conservation principles, Native people are guaranteed levels of harvest equal to their present levels. (s.24.6) With the exception of the vested rights mentioned above and access to certain commercial activities, non-Native hunting will be permitted only in relation to wildlife stocks in excess of current Native harvest levels.

Section 24.4 established a Coordinating Committee to supervise and regulate the Hunting, Fishing and Trapping Regime. It is a consultative body designated as "the preferential and exclusive forum for Native people and governments jointly to formulate regulations and supervise the administration and management" of the regime. (s.24.4.23) It consists of twelve people, with equal representation from the Cree, Inuit, Canada and Quebec. Governments must submit to the Committee, for advice prior to enactment, any proposed regulations relating to the Regime, and endeavour to respect the views and position of the Committee. If the government decides not to follow Committee recommendations, it must consult them again before acting. Among other tasks, the Committee will oversee the distribution of commercial fishing and outfitting rights.

Native local and regional governments are authorized, under s.24.5.4, to pass regulations concerning the conservation of wildlife on Categories I and II lands. Their jurisdiction includes the allocation of quotas as between Natives and non-Natives, licensing for quotas, and harvest methods. These locally or regionally proposed by-laws must be submitted to the Coordinating Council for its advice, and then to the responsible federal or provincial minister, who has 90 days in which to disallow it.

The Agreement is made subject to Canada's exisiting international obligations under the Migratory Birds Convention and the Whaling Convention (s.24.14). However, Canada undertakes to attempt to modify her obligations thereunder to the extent that they conflict or are incompatible with the Agreement.

The Inuvialuit Land Rights Settlement

This Agreement in Principle was signed on October 31, 1978 between the Inuvialuit of the Western Arctic and Canada,[31] and is a major step toward settlement of Native claims in the Yukon and Northwest Territories. Its wildlife provisions are primarily found in section 14, which emphasizes the need to protect critical wildlife habitat, and to employ the knowledge of both the Inuvialuit and the scientific community in achieving conservation.

Inuvialuit harvest rights include the exclusive right to harvest game on their own lands, which cover approximately 22 percent of the area they traditionally used. Furthermore, they alone may harvest furbearers, polar bear and musk-ox throughout the Western Arctic, although this is subject to the protection of existing rights for current trappers (s.14(2)(e)). They will have the preferential right to harvest all other species for subsistence purposes, and priority in the harvest of marine mammals, the latter guaranteed to current harvest levels. (s.14(2)(a)). Harvest methods include both traditional and present. (s.14(2)(i)). These rights must be exercised subject to conservation laws. Section 2(1) defines conservation:

> ''conservation'' means the management of the wildlife populations and habitat to ensure the maintenance of the quality (which includes the principle of long term optimum productivity) of these resources and to ensure the efficient utilization of the available harvest.

Section 14(4) (a) of the Agreement in Principle establishes the notion of a restricted entry system to control the taking of certain species (notably caribou) for the purpose of commercial sale for food. Factors determining who will benefit from the system include residence, past experience and performance, skills and social need. Other aspects of commercial activities, such as outfitting, will be determined in the Final Agreement (s.14(5)).

Government will have the authority to set harvestable quotas based on conservation principles, except in regard to furbearers, polar bear and musk-ox, where quotas will be set jointly by the Inuvialuit and government. (s.14(3)(b)) Subsistence quotas will be set jointly, taking into account the food and clothing requirements of Inuvialuit, their use patterns, the extent of the resource available, etc. (s.14(3)(c)).

Certain management institutions will be established, including an Inuvialuit Game Council and local Hunters and Trappers Committees. (s.14(6)). Initially, these bodies will be advisory, but will have the right to be consulted on legislative changes. A Natural Resources Research Board will be set up, consisting of both Inuvialuit and government representatives. These institutions are intended ''to

[31] *Inuvialuit Land Rights Settlement Agreement in Principle* (1978).

ensure legislation, policies, programs and measures that protect wildlife harvesting potential and biological productivity in the Western Arctic." (s.14(6)(f)).

The Future

Given the vast differences in the social, economic, and cultural situations of various Native groups in Canada, it is difficult to generalize about future approaches which may minimize conflicts between Native and non-Native wildlife users, and government. However, certain trends have been set in motion and are unlikely to be reversed. One is the negotiated settlement of Native land claims in the vast non-treaty portions of the country. All settlement proposals put forward to date by Natives have included special rights to harvest and manage fish and wildlife. The Quebec and Western Arctic Agreements demonstrate that government is willing to go some distance in responding to these demands. Special rights for northern Natives are likely to be mirrored with similar demands from southern Natives, as illustrated by recent developments on Indian reserves. In view of this reality, it is suggested that future dealings with Natives on wildlife matters should reflect the following principles.

First, harvest of fish and wildlife must be subject to the principle of conservation. I do not believe that this will be rejected by Natives, who have an obvious interest in protecting the resource. All recent agreements have been built upon this principle. This is not to deny that, on occasion, factual disputes about conservation may arise between Natives and others. As guardian of the broader public interest in protecting resources which often migrate to non-Native areas, government must retain the ultimate power to set allowable harvest levels. But conflicts between the Native and scientific perception of such issues must, to the extent possible, be resolved by mutual education and interchange, and not by the non-Native community's rigid insistence that it always knows what is best.

Second, special Native harvest rights must continue to be entrenched in law. Many arguments can be raised in support of this proposition. In parts of Canada, legal and constitutional history supports it, in spite of the fact that this has sometimes been overlooked or ignored by legislators. Our interest in promoting cultural diversity dictates that so important an aspect of the Native culture ought to be enhanced in every way possible. The stresses upon many Native groups through rapid exposure to change and to the dominant society's values suggest that there are social reasons for protecting Native hunting rights. Moreover, since Natives tend to live in areas of little economic potential or characterized by a boom-bust economy, certain economic arguments favor the idea of priority or preference for Native use of fish and wildlife.

Following from the second principle is the concept of user participation in wildlife management. Under current arrangements there are clear limitations to Native jurisdiction. But some emerging examples provide models for techniques of joint management and decision making. A continuing problem is that many wildlife managers have difficulty respecting the expertise of Native hunters which arises from experience and not from scientific learning. It is to be hoped that through joint management efforts such barriers will gradually break down. Collective initiatives will also help Natives appreciate the benefits of scientific technique and analysis.

The most difficult problem may be to resolve differences between Natives and those non-Natives who use fish and wildlife resources themselves or are committed conservationists. One important step, taken in the Western Arctic and Quebec agreements, is to ensure that certain non-Natives may continue their harvest activities. This relatively minor concession by Natives will have significant public relations benefits. In addition, negotiations between Natives and government regulators should be largely carried out in a public forum. This will help to allay fears that non-Native rights are being circumscribed, or that developing arrangements will lead to the destruction of the resource base.

Finally, interaction between Native and non-Native users must be encouraged, in order to exploit the common interest of both groups in conserving wildlife for tomorrow.

Federal, Provincial and State Government Perspectives

Management of United States Fish and Wildlife Resources and Special Rights of Native Americans

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Native Americans in the United States (colloquially described as "Indians," "Eskimos," or "Natives") have advanced special claims to the fish and wildlife resources. These claims fall into four categories, two of which will be discussed below.

First are claims arising out of treaties made between the United States Government and tribes and bands in the early history of the United States (terminating in 1871 when Congress by statute abolished treaties as a way to deal with Indians in the United States).

Additionally, in 31 states, Indian "reservations" exist, i.e., tracts of land set aside for the use of Indians. Many of these reservations have special jurisdictional status that affects the authority of the states (and the United States) to regulate the harvest of fish and wildlife resources (including migratory species) in those areas by Indians.

In statutes providing for regulation of fish and wildlife resources by both the United States Government and the various states, there is often specific statutory recognition of special rights for Indians. Most frequently, there is provision for subsistence harvest of fish and wildlife resources by Natives.

Finally, in some cases, a claim of "aboriginal" right has been raised and sometimes recognized. These claims are founded in the early occupancy of the lands by Indians and a claim that this somehow entitles them to special treatment or exemption from fish and wildlife conservation laws.

Only the first two of these will be discussed below. In light of the author's particular personal experience and familiarity with the problems or controversies in the Western states, the emphasis will necessarily focus on those states.

Treaty Rights

Treating with Indians in the Western Hemisphere was first mentioned in 1532 by an agent of the Emperor of Spain suggesting ways to deal with the "barbarians" in the New World. The first treaties by the United States were made, of course, after the organization of the Continental Congress. The first treaty, a treaty of alliance, with the Delaware Indians, was made September 17, 1778. As the nation expanded westward (in part with forceable removal of the Indians) treaties of cession were made, whereby any Indian claim of ownership of the land was extinguished by agreement which commonly provided for the Indians the right to continue to search for subsistence through hunting and fishing. One series of late examples are treaties made in the mid-1850s by the United States with Indian tribes in the northwestern part of the United States.

Early on, the existence of language guaranteeing hunting or fishing activity came into conflict with efforts by states to regulate this harvest.

Fishing

The first United States Supreme Court's consideration of treaty fishing rights involved those treaties which preserve a "right of taking fish at all usual and accustomed grounds and stations in common with the citizens of the territory." In *United States v. Winans,* 198 U.S. 371 (1905), the United States Supreme Court held that a private individual with state and federal patents to property along a river and a state license to operate a fish wheel could not totally prohibit treaty Indian access to their usual and accustomed fishing areas. The state's authority to regulate the fishing was recognized, however: "Nor does it [the right to take fish] restrain the state unreasonably, if at all, in the regulation of the right." In 1919, this decision which spoke of an easement to reach the usual and accustomed fishing places was extended to an area outside the area ceded by the Indian treaty.

In 1942, the court considered *Tulee v. Washington*, 315 U.S. 681 (1942), and held that the state could not require a general revenue fishing license. The authority to regulate treaty fishing was, however, again affirmed: "The treaty leaves the state with power to impose on Indians equally with others . . . restrictions of a purely regulatory nature concerning the time and manner of fishing outside the reservation as are necessary for the conservation of fish." The court, immunizing treaty Indians from some regulatory measures (licensing), lay the foundation for a controversy that has continued in the United States Northwest to the present, particularly in the State of Washington. It may finally be resolved in a case now pending in the United States Supreme Court.

The first action involving Fisheries and Game Departments of the State of Washington was instituted in state courts to define the treaty right and terimate the treaty fishing controversy. In *Puyallup I* (*Puyallup Tribe of Indians v. Game*), 391 U.S. 392 (1968), the court concluded:

> The right to fish at those respective places is not an exclusive one. Rather it is one "in common with all citizens of the territory." Certainly the right of the latter may be regulated, and we see no reason why the right of the Indians may not also be regulated by an appropriate exercise of the police power of the state . . . The manner of fishing, the size of the take, the restriction of commercial fishing and the like may be regulated by the state in the interests of conservation provided the regulation meets appropriate standards and does not discriminate against Indians.

Unfortunately, the court did not set out what the "appropriate standards" were or give any particular guidance on what constituted "discrimination" against the Indians.

The litigation continued. Indeed such vague language could hardly be expected to terminate a controversy which generated great emotion, not to mention the huge dollar values involved in the salmon and steelhead resources of the Pacific Northwest.

In *Puyallup II*, 414 U.S. 44 (1973), (the same case after remand returning to the United States Supreme Court five years later), the Court quoted with approval the above proviso as to the state's regulatory authority and held a total (statutory) prohibition on Indian net fishing for steelhead trout to be invalid where sports fishing was allowed: "The aim is to accommodate the rights of Indians under the treaty and the rights of other people."

Unfortunately, the standards enunciated in this case were also insufficient to resolve the controversy since the question of how much of the fishery could be preempted by Indians' nets had yet to be addressed.

In *Puyallup III*, 433 U.S. 165 (1977), the United States Supreme Court again considered this case, fourteen years after the commencing of the action. The court noted its earlier holding that "the exercise of that right [fishing] was subject to reasonable regulation by the state pursuant to its power to conserve an important natural resource." Even on-reservation fishing by treaty Indians could be controlled by the state. The court affirmed an allocation of a percentage of natural fish (excluding those propagated through hatchery systems) to the treaty Indians.

Even as the above litigation was underway and the state agencies were endeavoring to resolve the treaty fishing controversy in the *Puyallup* cases, individual Indians, Indian tribes and the United States Government were bringing actions against the state to broaden the interpretation of the "in common with" right of fishing. As noted above, the Supreme Court (and the state courts who considered the *Puyallup* actions) had recognized the right of the state to control Indian fishing where necessary for conservation. The actions filed in federal courts went far beyond this approach of defining the extent to which treaty Indian fishing is immunized from state regulation. An obligation was imposed on the states (and their fishermen) to provide a guarantee of fish to treaty Indians through restricting non-Indian fisheries.

(1) The first of these actions was *United States v. Oregon* (*Sohappy v. Smith*), 302 F.Supp. 899 (D.C. Ore. 1969). The judge ruled that commercial fisheries in the lower Columbia River, an extremely productive river system for anadromous fish, must be restricted so as to provide a "fair share" of fish to treaty Indians fishing in upstream areas. After the *United States v. Washington* "Boldt" decision mentioned below, that court amended its judgment to require 50 percent of the spring chinook to be provided treaty Indians. This judgment was later affirmed by the Court of Appeals but returned to the district court with the admonition that the 50 percent was not the necessarily correct formula, and the states could show what alternative formula was appropriate. Presently, a five-year settlement is in effect under which Indians get 40 percent of one chinook run and 60 percent of another.

The well-known "Boldt" decision is *United States v. Washington,* 384 F. Supp. 312 (E.D. Wa. 1974), 520 F. 2d 676 (9th Cir. 1975), cert. denied 423 U.S. 1086 (1976). Subsequent implementing orders are found at 459 F. Supp. 1020 (9th Cir. 1978). Certiorari was granted on October 16, 1978, to hopefully resolve the whole controversy.

Judge Boldt quoted with approval the analysis of the Sohappy court above and went on to direct that treaty Indians must be afforded 50 percent of harvestable fish together with on-reservation ceremonial and subsistence fisheries, none of which were to be counted in the 50 percent share. Finally in 1978, the United States Supreme Court agreed to review the Boldt allocation and related actions. Among the significant related actions which have been reviewed are an order of the federal district court extending the 50 percent allocation to fish and waters under the jurisdiction of the IPSFC. The International Pacific Salmon Fisheries Commission is probably more well known by Canadians here. It is an international commission established by treaty between the United States and Canada to manage the harvest of fish orginating from Canada's extensive and highly productive Fraser River system. Despite the fact that these fish are covered by a subsequent treaty with Canada, the federal court ordered a 50 percent allocation of the United States share to treaty Indians. In the first set of orders he authorized Indians disregard of certain IPSFC regulations and directed efforts to change the regulations to provide for special fisheries for Indians. In subsequent years, the United States Government has adopted special regulations for treaty Indians differing from those adopted by this International Commission, alleging that the federal court decision requires such.

The consequence of federal court determination that treaty language "right to fish in common with all citizens" as guaranteeing a specific percentage or number of the resource to treaty Indian fishermen requires for its implementation restrictions on non-Indian fishing activities to assure this number of fish. The Washington State Supreme Court has held on numerous occasions that such regulation prohibiting non-Indian fishing while allowing Indians to fish in order to guarantee them a particular share of the fishery is unlawful and violative of the United States and state constitutional requirements that all citizens receive equal treatment, and the constitutional prohibition on granting of special privileges and immunities. (That court held that separate statutory grounds indicated the same conclusion.) As significant as the constitutional conclusion that all citizens must be treated equally is the conclusion that the "in common with all citizens" treaty language does not indicate a different result. A similar conclusion was reached by that court with regard to the International Pacific Salmon Fisheries Commission regulations, holding that regulations must be applied equally to all United States citizens.

Not surprisingly, the federal courts have not agreed and in both Oregon and Washington have issued injunctions ordering all non-Indian fishermen to comply with regulations intended to provide the dictated share to treaty Indians.

Another interesting and somewhat ironic situation exists in areas in which the United States Government has now undertaken regulation of fisheries. These areas include the ocean fishery (from 3 (4.8 km) to 200 miles (320 km) off the United States coast) and now the regulation of the IPSFC fishery which the federal departments of Commerce and Interior have undertaken to regulate (Commerce passing regulations for non-Indians and Interior passing regulations for Indians). In each of these areas, the United States Government apparently does not feel obligated to provide the 50 percent plus to treaty Indians since regulations in neither area are designed to provide a 50 percent share.

As mentioned previously, the federal court orders of allocation, extension of the allocation to the IPSFC fishery, orders enjoining fishermen to comply with such a system together with the Washington State Supreme Court contrary decisions have all been appealed to the Supreme Court of the United States. The argument was held on February 28, 1979. A result is expected in or by June.

In the above discussion of special off-reservation rights of Native Americans, special emphasis has been placed on the Pacific Northwest of the United States. This is obviously true in part because of the personal familiarity of the author with claims and litigation in that area. Additionally, it is believed by the undersigned to be a "test" case; the most aggravated example of assertion of such special rights in the United States. Numerous claims, most of a more limited nature, are pending around the United States. It does provide an opportunity to identify the results of such a special entitlement and the effect on recreational and commercial fisheries and indeed the resource itself.

One clear result has been a breakdown in respect for regulations promulgated by the conservation agencies. Thousands of violators have been observed. It should be noted also that this disrespect for the regulation of the fishery has not been limited to non-Indian fishermen who presumably bear the burdens of the court decisions granting special rights to treaty fishermen. The experience of the United States Government agencies in enforcing the federal court order and federal regulations is quite similar to that of the state agencies, i.e., approximately one-third of the violators cited were treaty Indian fishermen (despite the fact that treaty Indian fishermen are a much smaller percentage of the fleet than one third). Existence of a widespread illegal fishery complicates management, of course. Inseason reports from a predictable or historically identifiable fishery are utilized for updates of run size. Distortion of normal fishing activities together with improper reporting (or no reporting at all) makes management more difficult. Only through extraordinary efforts to improve and improvise management systems has the system been kept at all under control. It is undoubted in some areas that the resource has suffered severely.

Hunting

One early United States Supreme Court considered hunting rights provided in a treaty, *Ward v. Racehorse,* 163 U.S. 504 (1896). In that action, the United States Supreme Court held that Wyoming could enforce its conservation laws even against an Indian whose tribe had a treaty with the United States preserving a "right to hunt," which treaty predated statehood, concluding that on becoming a state, Wyoming acquired the complete authority to regulate the killing of game within its borders just as one of the original states. Accordingly, the treaty language did not immunize the Indians from state regulation. Not much is left of the *Ward v. Racehorse* doctrine today, however. Generally where treaty hunting rights exist, the courts have perceived them as providing some special right over and above that enjoyed by other citizens, e.g., freedom from licensing. Additionally, the only recent United States Supreme Court case considering Indian hunting *(Antoine v. Washington,* 420 U.S. 194 (1975)), seems to indicate that Indian treaty hunting is now legally like fishing was in the *Puyallup* cases, i.e., it may be regulated where necessary for conservation. It is hoped that this exemption will continue to be narrowly construed to apply only to "subsistence hunting." The courts of at least Washington will allow this by not construing the exemption to the extent to allow the commercialization of animals or wildlife set aside for noncommercial uses by the states.[1]

In the area of treaty hunting, unlike that of fishing, there have been more cases challenging the applicability of federal statutes.

[1]The federal court in Washington specifically allows the commercial sale of trout categorized as a game fish by the laws of that state.

In a case in 1941, the federal district court held that the Migratory Bird Treaty Act, implementing an international treaty for the regulation of hunting of migratory birds, was inapplicable to Indians where hunting on reservation. (*United States v. Cuttler,* 37 F. Supp. 724 (D.D. Idaho 1941)).

More recently, three cases have considered the applicability of the Bald Eagle Protection Act to Indians. In *United States v. White,* 508 F. 2d 453 (8th Cir. 1974), it was held that an Indian could not be prosecuted for violating that act on a reservation. More recently, however, the Bald Eagle Protection Act has been held applicable to Indians. (*United States v. Willard,* 97 F. Supp. 429 (D.C. Montana 1975), a conviction for selling eagle feathers; *United States v. Top Sky,* 547 F. 2d 43 (9th Cir. 1976); and *United States v. Charlie Top Sky,* 547 F. 2d 486 (9th Cir. 1976) affirming convictions of Indians for sale of golden eagles and golden eagle feathers).

Several of the above actions such as *Cuttler* and *White* involved on-reservation activities of Indians. There, the states have generally not asserted jurisdiction to control Indian activities, but see *Puyallup, supra,* in which the United States Supreme Court affirmed Washington's exercise of jurisdiction to control fishing activities within the exterior boundaries of the former reservation.

In sum, the extent to which Indian hunting is free from regulation (either state or federal) is confusing and must be analyzed on a case-by-case basis analyzing applicable treaty, reservation, statute, etc.

A "Boldt-type" action has been threatened by the United States but not yet filed, in part at least because of the potential impact on federal statutes and programs.

A Special Case: "Subsistence" and "Ceremonial" Hunting and Fishing

There is specific recognition of a special right for subsistence and ceremonial harvest in many statutes and regulations, both state and federal. Through court order (as in *United States v. Washington*) or through agreement with tribes (as in the case of the Columbia River), such exemptions have also been made for ceremonial and subsistence fisheries. Whether or not this is appropriate as a matter of policy is a political decision. There are difficulties in administration of such a system. In the Northwest the resource under consideration is of extremely high economic value. There have been numerous and continuing problems of fish not being reported or being improperly reported as ceremonial and subsistence. On the Columbia River, in some cases even conservation closures recognize continued ceremonial and subsistence fisheries. The number of such fisheries has increased dramatically from 9 in 1975 to 77 in 1978. In the Puget Sound region where the federal court does not "count" those fish as part of the Indian share, the number has naturally shown a similar dramatic increase.

Similarly in British Columbia, where the Native or Indian harvest in the Fraser River is limited to a subsistence fishery (and similarly does not count in the division of catch between the nations), the catch is said to be in the hundreds of thousands of fish (approximately 300,000 in 1976).

The point is not to impugn Native American fisherman but rather to point out that where an economic incentive exists, loopholes or special exemptions in regulatory systems create management problems. Salmon caught in the Columbia River in a net marked ceremonial are just as dead and as unlikely to spawn and propagate the species as one caught in a net marked for commercial purposes.

More Confusion: Who Regulates Non-Indians on Reservation?

An additional area of confusion is whether states may regulate non-Indians while within the exterior boundaries of Indian reservations in their state. There is a split of opinion between the federal courts of appeal in the United States. In *Eastern Band of Cherokee Indians v. North Carolina Wildlife Resource Commission,* 588 F. 2d 75 (4th Cir. No. 76-2161, November 30, 1978), the court concluded that licensing requirements may not be imposed. However, *Colville v. Washington,* 412 F. Supp. 651 (E.D. Wash., 1976), as reversed 9th Cir. No. 76-3286, February 16, 1979, holds that Washington could regulate activities of non-Indians within the exterior boundaries of reservations. Other cases involving the states of New Mexico, Arizona and California are presently on appeal to the courts of appeals.

Once again, this is an area of substantial confusion with significant ramifications for management. The migratory nature of many of our wildlife resources makes uniform management systems at least over their range desirable. Additional enforcement problems are occasioned by judicial determination. If there are enclaves in which fish and wildlife protection rules are not applicable, the claim that an animal was taken "on-reservation" becomes a common one.

In light of the fact that the United States Supreme Court has held that the tribes do not have criminal jurisdiction over non-Indians within the exterior boundaries of the reservations (*Oliphant v. Suquamish Tribe,* 429 U.S. 1987 (1978)), the proper regulation of their activities requires either federal or state legislation. In the State of Washington, with over 20 reservations, many of them quite small and without full time federal enforcement, state regulation is preferable.

Conclusion

The creation or implementation of special rights to the fish and wildlife resources has been productive in providing employment for attorneys and work for the courts in the United States. The "Boldt" decision record shows over 5,000 separate documents filed with the lower court and over 200 separate court orders. Additionally, there have been approximately 20 appeals to the United States Court of Appeals and State Supreme Court, culminating in the United States Supreme Court action (which is itself a consolidation of three actions involving numerous lower court decisions).

All this litigation has not been productive for the resource, however. The time, money, and effort involved might much more productively been spent in efforts to protect and enhance the resource.

In the opinion of the author, the only long term solution which is consistent with proper management is a return to the principle of the United States Government that all men are created equal and are constitutionally entitled to equal treatment and equal participation in the use of these valuable natural resources.

Management of Fish and Wildlife Resources by Native Governments

Views of the National Indian Brotherhood of Canada

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National Indian Brotherhood
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On October 11, 1978, His Honour, Judge C.C. Barnett of the Provincial Court of British Columbia delivered a decision in the case of Regina versus Francis Hanes. Francis Hanes was charged with hunting moose out of season and the decision is pertinent to the topic we are considering today. Judge Barnett said:

> I am going to dismiss the charge of hunting the moose out of season without permit because I believe that your people have a *right* to hunt for food during *all* seasons. . . The Indian people believe that their rights to hunt for food should be considered before other people are allowed to hunt for sport. I say they are right . . . I have not decided this case on any narrow technical point. I say you are not guilty because you had a *right* to hunt the moose.

His Honour Justice Barnett arrived at his position after carefully considering the arguments of those opposed to special hunting rights for Indians. Upon hearing evidence of the guarantees given to Indians by the first immigrants to this land, Judge Barnett found in favor of the Indians.

Historians are virtually unanimous in their view that the early Treaties between the original inhabitants of North America and the white immigrants were extremely one-sided contracts—contracts that left the aboriginal peoples with very little in exchange for a continent. Nevertheless, although Indians who signed the treaties were unaware of the interpretations white governments would subsequently put on the contracts (and consequently were hoodwinked out of land and resources they never realized were being taken away) the Indians always insisted that special hunting and fishing rights be guaranteed in the Treaties. Indians have always viewed hunting and fishing rights as vital.

Not only have we been dependent on the bounties of the land for physical survival, but our religious, social and cultural systems have always been intimately bound to the natural environment as well. But history shows that governments and corporations have frequently violated the hunting, fishing, and other life-style rights so important to us.

We obviously see the need to carefully conserve and manage our wildlife resources. By doing so we assure the continuance of their use for ourselves and our children. Through wildlife conservation and management we will also ensure our physical, social, religious and cultural survival.

In this sense our concern with preservation and conservation of wildlife is similar to the goals of government agencies and private and public associations. These organizations state they also wish to maintain adequate wildlife stocks. Our conflicts have most often taken place with these groups when they attempt to regulate *our* natural, wildlife resources for the benefit of *their own* members.

Unfortunately, governments and private agencies are quite willing to trample on our aboriginal rights in order to preserve fish and game for their constituents.

Conservationists argue that Indians have abused hunting and fishing rights. This of course, is no reason to take away such rights from all Indians. This is analagous to taking away hunting and fishing privileges for *all* white people when some white people abuse these privileges.

I would like to make it absolutely clear that Indians endorse conservation practices. But whenever there must be a cutback in hunting and fishing in order to preserve wildlife resource, this cutback must first be made on non-Indian use of that resource. Indian rights must be a priority. This principle has not been enshrined in the past. Whenever a conflict arose between, for example, Indian use of a commercial wildlife resource and sportsmen's use of that resource, the rights of the sportsmen were frequently given precedence over Indian rights. The reason for this was economic. Sportsmen bring considerable dollars into hunting and fishing areas and local businessmen want their dollars. Consequently, considerable pressure has been placed on governments by businessmen to undermine Indian rights and to encourage sports hunting and fishing. Frequently this undermining of Indian rights has taken place by passing conservation laws—laws which in reality were designed for the benefit of white sportsmen.

Indians have carefully watched this process. We've also noticed how white governments and private associations have handled conservation policies. Unfortunately, we can't help but conclude that in most cases, governments and white associations have done a rotten job preserving our wildlife resources but an excellent job in abrogating Indian rights. Indians are determined to reverse this process.

Indian governments across the country are passing and enforcing Indian conservation laws. We feel the preservation of our environments and our wildlife, (and consequently the survival of our religious, social and cultural systems) are too important to leave any longer in the hands of people who have so obviously abused nature. The passing and enforcing of Indian conservation laws also re-establishes the Indian rights which were originally given to us by the Great Spirit and guaranteed by the first immigrants to our lands. If your organizations are truly interested in conservation then you will cooperate with Indian governments to preserve our wildlife resources. You will especially cooperate with Indian governments and their conservation laws if you believe that treaties between peoples should be honored and that promises made in legal contracts should be carefully kept.

In conclusion let me quote once more from the decision handed down by His Honour, Judge C.C. Barnett in the fall of 1978. He says:

> In a recent issue of *B.C. Outdoors*, a sportsmens' magazine, an individual who calls himself "Traveller" said this:
>
> "Although the average non-hunter and non-fisherman doesn't realize it, there is a major confrontation looming between Indians and well over 1 million hunters and fishermen in Manitoba, Saskatchewan, Alberta and B.C. The confrontation—it is closer to war in some areas—involves the Indians silly silly claim that they are entitled to hunt and fish out of season."
>
> This type of uninformed and irresponsible journalism only serves to fuel the fires of prejudice and discontent, both of which remain very much alive in 1978 in British Columbia.

We commend Justice Barnett for the wisdon he displayed in his decision. We only wish conservationists throughout North America would show as much wisdom.

Management of Fish and Wildlife Resources by Native Governments

The Northwest Fishing Rights Controversy: An Indian Perspective

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Quinault Treaty Area, Taholah, Washington

Abundant runs of salmon and steelhead once filled to overflowing the rivers of the Pacific Northwest. Over the course of a few thousand years, the aboriginal people who came to occupy the land developed an entire culture and economy around these plentiful fishery resources. The heritage of the Northwest Coast Indian is still founded upon the belief that the conscious spirits of all non-human, living things causes them to place themselves, voluntarily and compassionately, in the hands of the people during times of need. To these people the migration of the salmon and steelhead as they returned to the rivers of their origin, marked a special time of thanks and ceremony because it meant the renewal of life. The culture of the Northwest Indian was stable and continued to thrive until 200 years ago when the influx of non-Indian traders and settlers severely disrupted it.

Conflicts between the Indian and settlers mounted until it became apparent in the 1850s that a formal agreement would have to be secured to quiet the uneasy peace for all time. In 1854 and 1855, Territorial Governor Isaac Stevens negotiated a series of treaties on behalf of the United States with the indigenous Tribes of the Northwest. The treaties were designed to extinguish the Tribes' title to lands the government had designated for homesteading. Eventually five treaties were signed and ratified in the geographic area now known as western Washington. They were: the Treaty of Medicine Creek (December 26, 1854) with the Nisqually, Squaxin Island, Muckleshoot, Puyallup, and Steilacoom; Treaty of Point Elliott (January 22, 1855) with the Sauk-Suiattle, Upper Skagit, Swinomish, Snohomish, Duwamish, Suquamish, Lummi, Stillaguamish, Nooksack, Snoqualmie, Samish, and Tulalip; Treaty of Point No Point (January 26, 1855) with the Port Gamble Klallam, Jamestown Klallam, Skokomish, and Lower Elwha Klallam; Treaty of Neah Bay (January 31, 1855) with the Makah; and the Treaty of Olympia (July 1, 1855) with Quinault, Quileute, and Hoh.

In accepting the terms of the treaties, the Indian tribes relinquished their claims to millions of acres of land but reserved certain rights to hunt, fish, and gather the food essential to their lives as Indians. For its part in the bargain, the United States reserved small tracts of land for the exclusive use and occupancy of the Indian, agreed not to make war on the tribes, and promised to protect Indian rights reserved by treaty including their rights to fish at "usual and accustomed grounds and stations." Thus, these treaties were not a grant of rights to the Indian, but rather a grant of rights from the Indian to the non-Indian. The Indians reserved for themselves the rights they did not grant to non-Indians.

Indian treaties are the supreme law of the land protected by Article Six of the United States Constitution, and they bind the judges of every state: "anything in

State Constitutions or laws of any state to the contrary not withstanding.'' But non-Indian settlers and the state government paid little attention to treaties and forced some of the tribes to file suit to protect their fishing rights.

At the time the treaties were signed, Indian fishing was regarded as a convenience to supply the food needed for the settlers. But as the non-Indian population expanded, entrepreneurs sought to capitalize upon the abundant fisheries resources and began to develop their own fishing businesses. From an economic and biological standpoint, catching the fish when they returned to the rivers made the most sense. But this fishery was already occupied by the Indians so a large non-Indian fishery quickly developed which intercepted the fish first. With an increasing number of non-Indian fishermen, the fishery thus shifted its pattern of exploitation to locations where biological management of the resource became nearly impossible.

The burgeoning population and rapid industrial development which accompanied settlement of the territory brought more dangers to the resource. Spawning and rearing areas were destroyed by the environmental degradation that resulted from abusive land use practices and polluting industries. The salmon and steelhead which were once so abundant were soon in danger of extinction.

By the early 1900s the decline of the fish runs had become evident. In 1907 the State of Washington outlawed net fishing for salmon in all rivers except the Columbia. Indian fishing rights which had been guaranteed by treaty were prohibited by state legislation. The Indian found himself in a position where he could exercise his treaty rights to fish at his ''usual and accustomed'' places only under threat of state arrest.

Despite a declining resource base, the non-Indian fishery continued to expand tremendously and by 1913 Washington salmon runs had fallen to one-fourth of their previous levels. Indian agents were already deploring the severe depletion of the resource which formed the basis for the Indian's livelihood and economy.

Indian tribes continued in their attempts to assert and protect their fishing rights during the 1920s to the 1940s. The conflict grew and flared to major confrontations during the 1950s and 1960s. Despite Supreme Court rulings which recognized the validity of fishing rights claims in the Puyallup cases, the state continued to seek ways of circumventing the law under the pretext of resource conservation. Because the Indian fishery was, geographically, the last in line, the exercise of treaty rights was curtailed. A 1969 federal district court decision *(Sohappy v. Smith,* 302 F. Supp. 899) ruled that the state has a responsibility to regulate the fishery so that the Indians would have the opportunity to harvest a fair and equitable share. This landmark case marked a first vague attempt at apportionment which would form the basis for a more precise distribution formula that would be developed by the court in the ''Boldt decision'' *(U.S. v. Washington,* 384 F. Supp. 312).

In declaring his decision, Boldt stated that the state, which was ''in past responsible for prevention of full exercise of Indian treaty fishing rights, loss of income to the Indians, inhibition of cultural practices, confiscation and damage to fishing equipment, and arrest and criminal prosecution of Indians'' had violated both the rights of Indians guaranteed under treaty and its own regulations. Boldt ruled that in ratifying the treaties, ''the United States obtained for the settlers and for the subsequently admitted state only the right of equal access'' to the fishery.

Indian people have a federally protected treaty right to take fish whereas other citizens of the state have only a privilege to fish under state regulation. Under the "Boldt formula," Indians were entitled to the opportunity to catch up to one-half the total number available for harvest at their usual and accustomed places in addition to fish caught by them on reservations and fish taken for ceremonial and subsistence purposes.

	Total run
	− Escapement goals for run propagation
50%	− Prior interceptions by non-Washington fishermen
	+ On-reservation harvest
	+ Ceremonial and subsistence harvest
	Indian harvest by species and region of stock origin

Challenges to this formula in the Ninth Circuit Court of Appeals have determined that the right of Indians to have the opportunity to catch 50 percent of the off-reservation harvest is within the discretionary power of Boldt's court. Boldt's decision declared that Washington State's regulatory and enforcement program was unconstitutional as applied to treaty fishermen, and it restricted the state to regulation of Indian fishing only to the extent necessary to protect the resource.

Non-Indian, commercial and sports fishermen were enraged by the decision and publicly attacked the Indians and Judge Boldt. These groups relied heavily upon emotional appeal and claimed that the court-affirmed Indian fishing rights, made Indians "super citizens," and thus violated their own rights to equal protection guaranteed under the 14th Amendment to the Constitution. This argument has no valid basis in law, because the 14th Amendment does not preclude distinctions based on political status. Indian fishing rights are not special rights conferred to individuals because of their ethnic origin; they are instead political rights retained by Indian quasi-governments by virtue of their treaties with the United States.

The fisheries agencies of Washington responded to the Boldt decision by announcing its appeal to the Ninth Circuit Court and ultimately to the U.S. Supreme Court, and by continuing to manage for its non-Indian constituency. In 1975 the Ninth Circuit Court affirmed and the Supreme Court refused to review the Boldt decision. Indian treaty rights had been upheld as the law of the land. But these battles in the courts did not enable the Indians to enjoy their rights in peace. The recalcitrance of the State to recognize Indian fishing rights was by no means over.

The reluctance of the State of Washington to comply with federally secured Indian treaty rights was not seriously affected by the decision in *United States v. Washington*. With assistance from the Washington state court system the State of Washington successfully avoided serious implementation of the decision in *United States v. Washington*.

On August 12, 1976 the Washington State Supreme Court handed down the first of a series of rulings which would have a serious and destructive effect upon the Indian treaty right. In *Washington State Commercial Passenger Vessel Association v. Tollefson* the Washington State Supreme Court was faced with a challenge to the very power of the State of Washington Department of Fisheries to implement *United States v. Washington*. The non-treaty commercial fishing interest alleged that the State of Washington could only regulate for conservation, and could not curtail ocean fishing to make more fish available to other treaty and non-treaty fishermen. The court dismissed the case as moot saying that since the regulations had already lapsed there was no controversy before the court. However, the court did question the power of the federal court to enter the orders that it did, and further expressed concern about the manner in which the powers of the Department of Fisheries were exercised.

The ambiguity in the Passenger Vessel case was clarified in June of 1977 when the Washington State Supreme Court decided *Puget Sound Gillnetters v. Moos*. Again the issue was the power of the Washington Department of Fisheries to regulate non-treaty fishing in order to implement *United States v. Washington*. The Washington State Supreme Court ruled that the Department of Fisheries had no power to regulate and allocate fish between user groups who were of the "same class." By defining "same class" to include both treaty and non-treaty fishermen, the state court thus attempted to reduce a treaty right to the equivalent of a state fishing license. The court further suggested that even if the state had the statutory power to so allocate, the equal protection clause of the 14th Amendment to the United States Constitution would preclude such allocation as a denial of equal protection. Finally, the court indicated that the ultimate arbiter of state power was the Washington State Supreme Court decision that the Department of Fisheries had no power to allocate was binding and the last word.

Although the decision in *Puget Sound Gillnetters v. Moos* effectively tied the hands of the Washington State Department of Fisheries, it must be understood, however that prior to that decision the Department was not acting with diligence to implement the decision. State regulations notwithstanding, intervening federal court orders could have provided the Department of Fisheries with sufficient authority to implement the decision if the Department of Fisheries had so been inclined.

On July 21, 1977, the Washington State Supreme Court decided *Purse Seine Vessel Owners Association v. Moos*. This case challenged the applicability of special state regulations relating to the IPSFC fishery. The ruling of the Washington State Supreme Court was parallel to that in *Puget Sound Gillnetters v. Moos*. *Purse Seine Vessel Owners Association v. Moos* has no real long range impact because the federal government has assumed total management authority for fishing in "IPSFC waters." The state is not being called upon to exercise any regulatory authority.

The battle to protect treaty fishing rights, and the continued resistance of the state has not been limited to state court actions. The Indians continued to be denied their right to fish in their usual and accustomed places because they operated the last commercial fisheries. State run size predictions were consistently too optimistic, thus allowing a disproportionate share of the fish to be harvested by non-treaty fisheries. Because of conservation needs, Indian fisheries were repeatedly shut down, and the tribes frequently found themselves before Boldt's court to try to force the state to comply with his orders. Even while the tribal fishermen were forced to sit at the docks, the non-treaty marine fleets often continued to fish and freshwater recreational fisheries on the stocks often continued unscathed.

Over the last several years Judge George Boldt has been forced to enter orders which have significantly reduced the latitude of the Washington State Department of Fisheries in managing the fishery. These orders were entered reluctantly and only after high officials within the Department of Fisheries expressed, in open court, they were unable to provide any protection to the treaty right. Therefore, if Judge Boldt had not acted, the rights declared in Final Decision #1 would have been utterly vitiated.

Each order that Judge Boldt entered was appealed by the State of Washington to the Ninth Circuit Court of Appeals. Boldt's orders included a Management Plan for rational management of the resource. That plan had been agreed to by the Washington State Department of Fisheries biologists, yet when it was entered by the court, the state still appealed it. Additional orders were an allocation order, an injunction against state court interference with federal court implementation of the Boldt decision, and most importantly, an order entered against non-treaty fishermen, enjoining them from engaging in fishing activities contrary to orders of the federal district court.

Over the last several years many non-treaty fishermen have engaged in a willful and continuous disregard of federal court orders and state regulations which limited non-treaty fishing in order to protect the treaty right opportunity of Indian fishermen. Illegal fishing and unreported catches enabled the non-treaty fishermen to take thousands of salmon which should have properly been harvested by treaty fishermen. The state claimed it was powerless to do anything to stop the illegal fishing, and in fact, developed regulations distinguishing between conservation and allocation closures. These regulations had the net effect of encouraging violations by the non-treaty fishermen because Washington State Supreme Court decisions had already indicated that the Department of Fisheries could only regulate for conservation reasons. Therefore, if the State of Washington distinguished between allocation and conservation closures, the non-treaty fisherman could fish in allocation-closed waters knowing that he would be free from state court action. Each federal court order was ignored and appealed by the state. The state claimed it was powerless to stop illegal fishing.

Non-Indian fishermen now felt that their open disregard of federal court orders was legally founded as well as "morally right." Confident that the state courts would dismiss any cases brought before them, non-Indian commercial fishermen continued to take thousands of salmon which should have been harvested by treaty fishermen. The blatant disregard toward federal orders closing the non-Indian fishery eventually culminated in violence with the shooting of a fisherman by a state fisheries patrol officer. Renegade fishermen (the man who was shot was not even a state licensed fisherman) were getting rich disobeying the law, the Indian wasn't getting any fish, and the resource was in jeopardy. Chaos was rampant.

On the political front, the persistence of the non-Indian fisherman in disrupting and preventing any attempt to implement Indian fishing rights had succeeded in eroding the public confidence in the judicial system. Many non-Indians mounted a concerted and well-financed lobbying effort to try to convince Congress that the Boldt decision had caused them undue hardship and would have to be overturned before order could be restored.

On an individual basis the plight of some non-Indian commercial fishermen is indeed worthy of sympathy. Many who have been dependent upon fishing for their livelihood have been forced into debt, some have had to sell their vessels, and others have had to abandon a family tradition to find alternative employment.

The target for the blame has been collectively Judge Boldt, the Indians, and the federal government.

But the target for the malice can hardly be justified upon a careful examination of the commercial fishing industry. The crisis presently confronting the salmon fisheries in the Northwest was not the result of recent court actions regarding Indian treaty rights. The Boldt decision merely precipitated the events which were already well in process. There were simply too many fishermen to be supported by the resource.

The Indian generally fished where runs were concentrated and used labor intensive methods, while the non-Indian fisherman has operated on dispersed, mixed stocks in a capital intensive fishery employing expensive equipment in economically inefficient ways. Increasing demands for fish and resultant price increases have lured more and more fishermen into the industry. From 1937 to 1977, the numbers of Washington State fishermen increased dramatically, a Canadian ocean troll fleet burgeoned, and a recreational fishery grew to the point where over a half-million anglers enjoy the sport of fighting salmon or steelhead. Catches, however, have not kept pace with the growth of the fishery (Table 1).

The actual decline in the resource base is greater than the catches alone indicate because improvements in fishing technology have increased the range and efficiency of the fleet. The productive capacity of the resource could not withstand the tremendous increase in pressure which has occurred over the last few years. Where the resource was once harvested primarily when mature adults returned to rivers to spawn, the fishery developed to exploit the resource at many different stages of the fish life cycle. A summary of the current harvest pattern of the fishery is presented in Table 2.

Foreign fisheries deserve special note because Indian treaty rights have been substantially diminished by bilateral agreements between the United States and Canada. A special management body entitled the International Pacific Salmon Fisheries Commission (IPSFC) regulates the fishery on sockeye and pink salmon destined for Canada but passing through United States waters. This fishery presently accounts for approximately 50 percent of the total salmon harvest for Washington State fishermen. In return for allowing a United States fishery on Canadian sockeye and pink salmon, Canadian fishermen are allowed to catch large numbers of chinook and coho salmon which are destined for Washington waters. The net result of this bilateral agreement is that the Indian fishermen who either lack the equipment, the desire, or the legal ability to participate in fisheries outside their usual and accustomed areas end up the losers. Although the Boldt decision ruled that Indians have the right to harvest 50 percent of the United States catch under the jurisdiction of the IPSFC, even with the provision of

Table 1. 1977 Licensed fishing vessels and catch per vessel expressed as a percentage of 1937 levels.

Method	Licenses	Catch
Purse seine	183%	29%
Gill net	213%	50%
Trollers	795%	22%

Table 2. Harvest pattern of the Northwest fishery. Key: * = minor fishery; + = major fishery; I = primarily Indian fishery; B = Indian and non-Indian fishery; and blank = negligible fishery.

Fishery	Chinook						Coho						Sockeye						Chum						Pink						Steelhead					
	1	2	3	4	5	6[a]	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sport	*	+	+	+	+	+	*	+	+	+	+	+						+					*					+	+	+	*				*	+
Troll		I	B	B	B					B	B					B	B					*	*					*	*							
Gill net		B			B	I					B	I					B	I					*	I					*	I					B	I
Foreign			+	+						+						+						*						+								
Purse seine		B						B									B						*							B					B	
Reef net					B						B						B						*						*						B	
Beach seine						I						I												I						I						I
Hook and line																																				*

[a]1. = freshwater juvenile; 2. = saltwater inside immature; 3. = ocean immature; 4. = ocean mature; 5. = inside mature; and 6. = freshwater mature.

special fishing times, treaty fishermen have been allowed to catch only 18 percent of the sockeye, 8 percent of the pinks, and 13 percent of other species.

Strong associations of fishermen and processors that are involved in the multimillion-dollar salmon fishing industry have the capacity to raise substantial sums of money with ease and thus carry a concommitant political clout that readily dwarfs the voting power of the Indian people who represent less than 0.5 percent of the populations.

The non-treaty commercial fleet is characterized by small numbers of full time fishermen (for example, during the period from 1972–5, 8 percent of the troll fleet landed 50 percent of the troll harvest and 17 percent landed 75 percent). Large numbers of part-time fishermen (for example, trollers are less than 43 percent dependent upon income from fishing on Washington salmon, Puget Sound gillnetters, 56 percent, and Purse Seiners, 63 percent); vessels which can be equipped with different types of gear (for example, a boat may be used as a troller and gillnetter), and fishermen who fish in a variety of places such as Oregon or Alaska (for example, landings in Alaska accounted for 40 percent of the income for vessels used as trollers-purse seiners, 27 percent for purse seiners, 20 percent for trollers-gillnetters, 12 percent for gillnetters).

The growth of the ocean fishery has caused other problems for Indian fishermen. Another management body entitled the Pacific Regional Fisheries Management Council regulates salmon fisheries in the area from 3 to 200 miles (4.8-320km) off shore under the authority of the Fisheries Management and Conservation Act. Although Indian fishing rights are as much a part of the law of the land as the constitution of the United States, members of the Washington Congressional delegation have recently pressured the Council not to manage the fishery so as to insure that Indians can have the opportunity to fish.

In addition to a large commercial fishing fleet, over half a million outdoorsmen presently enjoy the sport of fighting a salmon with rod and reel. Each year these recreational fishermen catch enough fish to equal approximately 22 percent of the commercial salmon harvest in Washington State. While the average catch reported by recreational fishermen is three fish, like the troll fishery, the recreational fishery is characterized by a small percentage of fishermen who catch a large number of fish. Because of the sheer magnitude of the potential participant population, the recreational fishery poses a very real and substantial threat to the health of the commercial fishing industry and the resource. Yet because of the voting power this group of sportsmen represents, the recreational fishery has been allowed to increase virtually unchecked.

Thus high seas interceptions of many Washington salmon stocks have been subjected to harvest rates which have not only denied Indians an opportunity to fish, but have also seriously jeopardized the viability of the resource. The ocean interception problem is so severe that indeed even artificially propagated hatchery stocks are being endangered.

Throughout the initial period of industrial development, industry and government believed that regulation or conservation of the fisheries resource was unnecessary because the natural runs could be easily replaced by hatcheries. From the time the first salmon hatchery was constructed in the state, this blind faith in hatchery production has been a principal factor responsible for continued careless exploitation. Because hatchery stocks can generally sustain higher rates of harvest than natural stocks, harvest rates have been allowed to exceed the natural reproductive capacity of the resource. For a while the hatcheries appeared to be able to compensate for the decline, but the fishery continued to expand, the fish continued to decline, and the demise of the resource became inevitable.

Harvest levels have decreased substantially over the past few years, not as a result of the Boldt decision on Indian fishing rights, but because the resource itself has been overexploited. In the three years since the federal court ruled that treaty fishermen must have the opportunity to take at least 50 percent of the harvest, the Indian catch has crept up to only 13 percent of Washington landings, a distant third behind non-treaty commercial and sports fisheries harvests. (By species Indian catch has averaged: Chinook, 18 percent; Coho, 15 percent; Sockeye, 10 percent; Pin, 7 percent; Chum, 36 percent).

The decline of the salmon fishery has also served to exacerbate the dispute in other ways by increasing the economic dependence of many tribes upon steelhead and thus heightening the conflict with sportsmen who prize the fish for its fighting qualities. To many "steelheaders," the harvest of the fish in nets or traps is abhorrent. Large numbers of sportsmen have exerted pressures individually and through organizations to win some Congressional support for decommercialization of steelhead. The sportsmen argue that since the economic value of sport-caught steelhead far exceeds its commercial value, the fish should not be commercially sold. The tribes, however, benefit hardly at all from an abstract value placed upon a sports caught fish; they consider the steelhead as another species of salmon and harvest the fish as a part of their cultural heritage and food as well as for the financial returns from the commercial sale of the fish. Because the salmon resource has been so depleted and subjected to such high catch rates before the Indians have their harvest opportunity, and because steelhead are not exploited by prior interceptions nearly as heavily as salmon, steelhead represents the only assured source of income for many Indian fisheries.

The tribes believe that the objection of sportsmen to the Indian harvest and sale of the steelhead is emotionally rather than rationally based. Impacts of Indian river fisheries have been greatly exaggerated by sportsmen and state management agencies. As an example, in the 11-year period prior to the 1969 litigation in *Department of Game v. Puyallup,* sportsmen took 89 percent of the total steelhead harvest *after* the fish had been subjected to an Indian net fishery. Healthy commercial and recreational fisheries have coexisted in coastal rivers for many decades and it is in these same rivers where sportsmen seek their trophy fish. There is no reason, save the emotional involvement of large numbers of sportsmen, why both Indian commercial and non-Indian recreational fisheries cannot operate on the same rivers. Decommercialization of steelhead represents an expedient and grossly simplistic attempt to resolve a complex problem which would deprive Indian people of their treaty rights while failing to serve long-term interests of either the sportsmen or the resource.

Furthermore, the decline in salmon fisheries coupled with concomitant resource habitat destruction through abusive land use practices and general environmental degradation have forced even those tribes with historically strong fisheries on-reservation, to fish off-reservation to earn a livelihood. Thus the conflict continues: fewer fish, more disputes.

In attempting to exercise treaty rights affirmed by federal court decisions, Indian fishermen have been shot at by angry non-Indian commercial and sport fishermen. Their equipment has been vandalized, and their fishing opportunity has been effectively vitiated by the conduct of local fishermen associations which have operated their fishery so as to frustrate Indian harvest. The tension and controversy resulted in a predictable hostility that surfaced a deeply ingrained resentment against Indians and against the Federal Government for its support of Indian rights. Indian people have had friends turn into enemies overnight, have been harassed in their homes and ridiculed in public places. Now they are threatened with the unhappy prospect of a unilateral redefinition of their treaties by Congress and decreased federal financial support for their education, health, social, resource development, and legal needs because an unfriendly Congressional delegation seems more interested in settling a volatile political issue than upholding the Constitution of the United States and the legal rights of a small minority of people. This backlash phenomenon was not limited to just Indian fishing rights in the Northwest. Throughout the nation, articulate and very well financed special interest groups have waged a concerted campaign to defeat Indian claims for land, water, and other resources. Many elected officials, anxious to capture this power base of votes, have been quick to introduce anti-Indian legislation to be heroes to their constituency.

There are many people in this land who do not want to recognize the obligations of the nation toward the Indian. They ask why should the Indian be treated differently? They say that Indian fishing, water, and other rights will make them bear too great a personal hardship. They say Indians are a small minority which has been "given" a "disproportionate and unfair" share of the fish by the Federal Court. They say that the Indian treaties are too old and therefore should not be honored. What they really mean is that Indian treaties no longer suit their convenience and should therefore be tossed aside. The Indian people are very sad that some so-called public servants seem so bent upon serving themselves that they are willing to abandon moral and legal principles to capture the support of this emerging power-base of voters.

Despite indisputable and overwhelming evidence to the contrary, the Indian has served as a scapegoat as the causative factor behind the decline of the fishery. In April of 1977, the Washington Congressional delegation succumbed to pressure and convinced President Carter to establish a special Presidential Task Force. The Task Force was to consist of representatives of the Attorney General and Secretaries of Commerce and Interior, and was to attempt to resolve the conflict between Indians and non-Indians. This task Force effectively took the "heat" off the delegation, and provided an opportunity to bring the combined forces of the Administration and Congress to bear on a controversial problem. To the Indians who had waited over a hundred years to have their rights protected, the prospect of negotiating those rights away was unpalatable. Regardless, the Washington State delegation mustered all its power to force the Indians to the "negotiating" table.

To the Indian, the right to fish is more than a right to harvest a resource for profit. It is an integral and inseparable part of the Northwest Indian heritage. The Indians have fought for more than a century to have their rights recognized and will not relinquish those rights willingly. Though the non-Indian fishermen would understandably like the Indians to quit pursuing their rights, this will not happen.

The tribes do not intend to be good little Indians and "negotiate" away what few rights they have left to further the political ambitions of those whose friendship must be bought with Indian sacrifices.

The Indian tribes of western Washington have always been anxious to work with the Federal Government, the State of Washington, non-treaty fishermen, and any other interested party toward the constructive resolution of the many complex and emotion-charged problems which presently plagues fisheries resource management. They have been willing to sit down and openly discuss the fishing rights issue with anyone to try to reach workable solutions which recognize economic, emotional, and political realities, but which also recognize Indian rights. They neither desire nor deserve the hatred which endangers their lives, property, and legal rights. Certainly no one wants to see the fishing dispute settled more quickly and amiably than the Indian people. They want to be able to exercise their treaty rights in peace and harmony with their neighbors, but they must have justice. The tribes do not wish to be adversaries, but they will defend tenaciously the rights reserved for them by their ancestors and guaranteed to them in their treaties. The court did not give the Indians the right to 50 percent of the fish. They merely recognized the validity of treaty rights, so long neglected and unprotected by the Federal Government that powerful and vocal groups have come to regard Indian property as their own.

A year ago the tribes viewed the formation of the task force with both anxious anticipation and apprehension. Superficially, the task force appeared to be an excellent mechanism for tentative resolution of complex Indian fisheries problems. The combined resources of the Departments of Justice, Interior, and Commerce supported by the force of the Administration and Congress represented a tremendous opportunity for substantial progress to be made. Looking deeper into the Task Force, however, there were unmistakable danger signals lurking in the shadows and many more have since emerged. Is the formation of the Task Force a genuine attempt made in all good faith to develop fish propagation programs and ease the impact of federal court decisions? Or rather, is it a cleverly disguised tool designed to enable those who do not wish to abide by the law to negate Indian treaty rights? The tribes were very well aware that if it is used improperly, the Task Force could easily become a subtle, insidious vehicle to initiate a new era of abrogation of Indian treaty rights that could easily lead to termination.

On January 16, 1978, the Task Force published the document *Porposed Settlement for Washington State Salmon and Steelhead Fisheries*. This plan reflected the mood of the public and the Washington State delegation in that it provided that the Indians make substantial reductions in their court-determined treaty rights. The vociferous emotion-filled arguments made by the non-Indians had taken their toll, and Indian treaty rights again appeared ready to fall victim to political expediency.

Shortly after issuance of the first settlement offer, the tribes and the State of Washington entered into a series of discussions in order to try to resolve their differences. Many of the complex and emotion-charged disputes which have strained relations between the Indians and their neighbors to the point where destruction of both the resource and the fishery have been threatened were explored and the tribes further agreed to attend a series of meetings with the State of Washington to discuss allocation questions. Several commercial and sports user groups served in an advisory capacity to the state during these discussions. This exchange of information and viewpoints has helped resolve parts of the dispute and will hopefully resolve more as the sessions continue.

On April 24, 1978, the Ninth Circuit Court of Appeals affirmed Judge Boldt's takeover of the fishery. In making its ruling the court felt compelled to state the reason for such extraordinary action on the part of the District and Circuit Court:

> Agencies of the State of Washington and various of its constituencies continue to attack the judgement in *United States v. Washington*. Accordingly, we will again set forth the treaty basis of the decision and reaffirm its validity. The State's extraordinary machinations in resisting the decree have forced the District Court to takeover a large share of the management of the State fishery in order to enforce its decrees. Except for some desegregation cases (citations omitted [sic]) the District Court has faced the most concerted official and private efforts to frustrate the decree of a federal court witnessed in this century. The challenged orders in this appeal must be reviewed by this court in the context of events forced by litigants who offer the court no reasonable choice.

The state's inability and unwillingness to enforce treaty rights should not be considered a new development following the entry of Final Decision #1. Judge Burns in concurring in the affirmance of Final Decision #1 by the Ninth Circuit Court of Appeals took the time to make the following observation:

> . . . although I recognize that District Judges cannot escape their constitutional responsibilities, however unusual and continuing duties imposed upon them, I deplore situations that make it necessary for us to become enduring managers of the fisheries, forests, and highways, to say nothing of school districts, police departments and so on. The record in this case, and the history set forth in the *Puyallup* and *Antione* cases among others make it crystal clear that it has been a recalcitrance of Washington State officials (and their vocal non-Indian commerical and sport fishing allies) which produced the denial of Indian rights requiring intervention by the District Court. This responsibility should neither escape notice nor be forgotten.

In June 1978, the Regional Task Force submitted a massive 348 page document entitled *Settlement Plan for Washington State Salmon and Steelhead Fisheries* to the tribes and to the National Task Force in Washington State fisheries. Like the Settlement Plan which had been prepared six months earlier, this plan did not call for implementation of the law under federal court decisions, but rather required Indians to forego the exercise of their treaty rights in favor of non-Indian fishermen.

The Settlement Plan would require Indians to "forego" exercise of their rights to fish commercially for steelhead, reduce the exercise of their rights to harvest salmon from 50 percent to 30 percent, give up access to the courts where treaty rights have been upheld, and accept substantial diminishment of tribal authority to regulate their own fisheries. In return the tribes have been promised more fish (not a larger share) in the future when production of the resource supposedly increases due to federal funding in enhancement projects and hatchery facilities. The conclusion is inescapeable: the Settlement Plan represents a document designed to circumvent the law and take away rights of Indian people.

The Settlement Plan is now being used as a blueprint for development of implementing legislation designed to "resolve" the Indian fishing controversy in

Washington State. Even further losses to Indian rights can be expected to occur during this legislative process.

It is regrettable indeed that the Presidential Task Force on Indian Fishing Rights has apparently capitulated to the will of power politics and thus has given up a tremendous opportunity to honor the promise of the federal government with integrity and restore the health of the salmon and steelhead resource. Continuation of the fishing controversy will continue to place the viability of the resource and the livelihood of the fishermen in serious jeopardy.

The solution to the fishing dispute does not rest upon destruction of Indian rights, as members of the Task Force and Congress evidently believe. Rather proper management could both save the resource and do much to help resolve the controversy.

The Boldt decision, perhaps by virtue of its controversial nature has presented a real opportunity for rehabilitiation and improved management of the fisheries resource. The tribes believe that the future health of the fishery will be determined by the willingness of all parties to recognize and respect the needs of those who depend upon the resource for their livelihood or enjoyment. Fishing rights are important parts of Indian cultural heritage, and they are protected by treaty and Federal law. Non-Indian fishermen have participated in the fishery for several decades and they too wish to pass their way of life to future generations. The tribes are convinced that open communication and candid discussion are essential to the resolution of long standing problems and to the development of a plan that can best accomodate the varying interests of different groups, meet legal requirements, and protect the resource.

Everyone who depends upon the resources has a pecuniary interest *and* a moral obligation to manage the salmon and steelhead with all the care, diligence, and skill at his command. The resource must be managed with conservation as the governing principle. No one can afford to sacrifice the resource for short term gains only to see the resource and the industry destroyed tomorrow.

It is difficult to forget that the history of this country is replete with many sad examples where state and federal governments have failed to deal honestly and sincerely with the Indian people: What promises will be broken in the future? Thus yet another chapter in the long and shameful history of the United States toward its Indian citizens is in the process of becoming history. Once again the interests of a small minority of people are being sacrificed to appease the insatiable appetite of the political machine. The experience of the Northwest Indians in trying to protect their rights should serve well to remind all the citizens of the world that eternal vigilence is necessary, even in this nation which purports to pride itself upon its respect and concern for the interests of its minorities, to protect against wrongful and deliberate oppression.

To the Indians of the Northwest, the fishing rights issue is not one of popularity or re-election, rather it is one of survival. They have fought long and hard to have their treaty rights upheld by the courts. Their rights to fish for the salmon and steelhead which formed the basis of their economic and cultural heritage are as much a part of the law of the land as the Constitution of the United States. If the federal government should once again choose not to honor its treaty obligations with dependent Indian Nations because doing so would be too inconvenient or unpopular, then it should do so openly and take by force what cannot be bought with money or promises. While the Indians may lose what little they have left, their demise will come quickly and they will die a proud and honorable death. They will understand and you will have the tears of their pity.

Management of Fish and Wildlife Resources by Native Governments

Indian Hunting and Fishing Rights

Hans Walker
U.S. Department of the Interior
Washington, D.C.

It has been noted this morning that Indians as citizens of the United States should have the same rights, privileges and responsibilities as other citizens with respect to all resources within a state. The argument proceeding from that status of Indians is that claims to special hunting and fishing rights by Indians violates the equal protection clause of the United States Constitution.

That argument might have some merit if there were a present grant of hunting and fishing rights to Indians, but even that can't be conceded in light of *Morton v. Mancari,* a case in which the Supreme Court has recognized that the treatment of Indians on a separate basis than others rests on political recognition of a quasi-sovereign entity rather than on discriminatorily favored treatment of a racial group.

But the rights of Indians need not and do not rest on a theory of grants from the federal government; they rest instead on the reserved rights doctrine—a reserved property right which has existed since time immemorial. The distinction between a reserved right and a present grant is an important one and I want to take a few minutes to elaborate on the derivation of the Indians' right.

Let's start from a point about which there can be no argument—before the white man set foot on this continent. At that time Indian tribes were in physical possession of all the lands and had control over all the game on those lands. They had political control, such as it was, over their territories. Then came the "discovery" of this continent. Unknown to the Indian tribes was the fact that they were enveloped upon discovery by legal principles which would have a profound effect on their lives. In the law of nations at that time was the rule that the discovering nation acquired legal title to the lands discovered and the Indians possessed only a right of use and occupancy. Only the sovereign could extinguish that right of use and occupancy.

When the United States came into being, it adopted the same rule. The United States then, under its law, possessed legal title to the lands and the Indians possessed only rights of use and occupancy. There followed the era of Indian land cessions—treaties and agreements whereby the Indians ceded large areas of their domain, reserving successively smaller tracts. The United States as party to the treaties and agreements then acknowledged the Indian title in the areas reserved—that title called "recognized title" raised the status of the Indians title to a higher status than that of only rights of use and occupancy. That is, their rights were now vested property rights subject to protection under the Constitution from taking without compensation.

Now, where does all this talk about land get us with respect to hunting and fishing rights? It gets us to the foundation of tribal rights. Those hunting and fishing rights stem from the reservation of land areas which would be used as Indian lands are used. It was decided very early on in a case called *United States v. Winans,* that such use of land (the Reservation) included the right to hunt and fish. The question in that case, where an Indian tribe reserved a tract of land when it ceded a larger portion, was whether it reserved a hunting and fishing right although there was no express language reserving such a right. In other words, was a right reserved by implication? The Court noting that hunting and fishing was as much a part of life for the Indians as "the air they breathe" upheld that right within the area reserved.

While the majority of the reservations do not expressly reserve a hunting and fishing right and thus are dependent on the *Winans* doctrine, some treaties—for example, the so-called Stevens treaties in the Northwest—expressly reserve fishing rights in off-reservation areas.

In conclusion, then, we can see that these rights then are not present grants nor even ancient grants—they are vested property rights which belonged to the Indians before there was a United States. The United States has formally acknowledged those rights in bargains with Indian tribes. Those rights, as vested property rights, deserve the full protection of property given by law to other property in the United States. If the equal protection clause of the Constitution has any application here, it is in this sense—that here is a property right which is entitled to be enforced and to be protected equally with other property rights. Any notion that the Indians' right violates the Constitution because they are being given a special or "super citizen" rights is without substance when you fairly examine the origin of those rights.

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