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Formal Opening

Daniel A. Poole
President
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Washington, D.C.

The theme of this year's Conference, "Many People, Many Demands, One Land," is an appropriate theme for all time. As human population increases, demands on land rise apace. Yet the total land base against which the demands are made remains fixed. And the byproducts and technical materials produced by society, some patently inconvenient and others starkly hazardous, reduce the land's capacity to accommodate man's needs and desires.

Certainly, intelligent planning and sensitive custodianship can increase or maintain renewable natural resources and extend the availability of those that are not. But in face of mounting population and demands, the costs of planning and management become greater and the necessity for doing so becomes more urgent.

The focus of the North American Wildlife and Natural Resources Conference is, and always has been, fish, wildlife and the traditional kinds of recreation and nature appreciation associated with the outdoor environment. Yet the concerns of the hundreds of resource professionals and conservation-minded persons who attend this meeting are, and must be, much broader than that. Fish and wildlife, the same as man, need a safe environment. And as valuable as they are in their own right, they serve as early-warning indicators of threats to the quality of man's environment.

It was individuals representative of interests present here, for example, who first detected and helped raise many of the so-called environmental issues to their present level of national concern. The disappearance of aquatic life and the impoverishment of vegetation foretold the dangers of acid rain and other air pollution. The reproductive failure of certain birds alerted man to the hazards of persistent chemicals. The list of examples is long and is ignored at peril.

It would be satisfying this morning to report that these relationships are well understood and accepted in today's Washington. To do so would be to misrepresent the situation.

It is a matter of grave concern to many that the Reagan Administration's reshaping of the thrust of government is posing a threat to environmental and conservation programs. It is an Administration's prerogative to plan and budget as best suits its aims and purposes, but the Administration's belt tightening grips the inflated federal midriff unevenly. Environmental and conservation personnel and programs are being cut back sharply, while at the same time, environmental and conservation losses will accelerate because of other Administration initiatives.

Not all resource agencies are affected the same, but the differences are mainly a matter of degree. Except for things military, science, research and management have few supporters among those doing the budget cutting. Federal agencies have lived through periods of budget depression before, but what is happening in Washington portends more than temporary setbacks.

Some of the Administration's appointees clearly find the fiscal situation a convenient screen to attack programs they oppose. Some who serve in leadership and policy roles are openly disdainful of federal agencies, their employees, and the agencies' congressionally mandated missions. Their attacks are being launched at all levels—at appropriations, policies, personnel and regulations.

To observe this, one need look no further than the Bureau of Land Management, administrator of the Federal Government's largest and among its most valuable land holdings. In rapid-fire policy switches and regulations reversals, and in changed management style, and disregard for the counsel of professional staff, the agency is re-emerging as a compliant accomplice of the interests that always have coveted the public lands. And pretty much have had their way on them.

It was as recent as 1976, you will recall, that by its passage of the Federal Land Policy and Management Act—the so-called BLM organic act—Congress dragged the agency across the threshold of the 20th Century and vested it with badly needed policy directives and multiple-use management authorities. Gains made since then by BLM now are being erased by selective budget cuts, policy shifts, staff intimidation, and relaxation of regulations guiding private use of public lands. The Administration's deliberate drive to increase returns to government from the public lands and to remove barriers to permittees' freer use of the public lands is unreceptive to professional advice and counsel.

In BLM's fiscal year 1984 budget request, the Administration is recommending the agency's biological staff and funding be reduced by 25 percent and 30 percent, respectively. And this at a time when grazing, energy, minerals and other uses of the public lands are being encouraged. This means that plans for the use and development of public lands will undergo little review, if any, of their potential impact on fish, wildlife and other resource values. Gains in BLM's overall 1984 budget request are for expansion of use and development and land sales. The loss is in resource management.

This morning I am not going to attempt a recitation of the many ways in which the federal environmental and conservation effort is losing momentum. They are being reported regularly in the conservation and environmental press.

A bright spot that deserves mention is the Secretary of the Interior's personal interest in extending and accelerating the national wetlands protection program. Unless action is taken in this session of Congress, some phases of the program, under law, are slated for severe slow-down beginning this fall. The Secretary has taken a keen interest in this issue and is actively helping to fashion a program to slow the needless destruction of America's wetlands.

Unfortunately, there are other things going on with the Administration, like the Army Corps of Engineers' evisceration of the Section 404 wetlands protection regulations, that would speed the destruction of America's wetlands. The Congressional Research Service of the Library of Congress says Section 404 "is clearly the key program in federal wetland management."

We must guard against sportsmen being asked to pay more to help save wetlands, while government continues to offer money, technical assistance and other incentives to destroy these vital areas. This has been a long-time problem during several Administrations. The right hand pays no attention to what the left is doing.

A closing observation. Successive administrations have been blind to the fact that fish and wildlife are highly cherished aesthetic and recreational resources. In 1980, 42.1 million American men and women, 16 years and older, fished; 17.4 million hunted; and 83.2 million were actively involved in watching, photographing and feeding wildlife. Many uncounted millions of younger persons also enjoyed these same activities. More than one-half of our national population participated, spending close to $50 billion, and creating thousands of jobs and enriching local, state, and federal governments. Fish, wildlife and the outdoors are of great and direct importance to at least 1 of every 2 Americans.

The tremendous value these many Americans and others attach to their "environment"—if I may use the word in its broadest sense—also has been demonstrated in one national poll after another. It is amazing and disappointing that the nation's political parties, which claim to be sensitive to the public interest, fail to recognize this fact.

No party lines are involved with Americans' love of the out-of-doors. By and large, people of all political stripes want even-handed, consistent, and diligent effort made to protect and perpetuate clean air and water, fish and wildlife, national forests, parks and public lands, and all of the rest. They are willing to pay more for it if need be, but they want their payment to result in positive results.

The political party or interest group ignoring this does itself, the public and the country serious disservice.

Old Style Conservation—Once Again into the Breach?

Henry L. Diamond
Chairman
Outdoor Recreation Policy Review Group
Washington, D.C.

It is a privilege to be here to speak to the foremost national gathering of resources management professionals.

In coming to talk about the need for a review of outdoor recreation policy, it is in a very real sense the closing of a circle that began 25 years ago. The leadership that helped create the landmark Outdoor Recreation Resources Review Commission (ORRRC) was from the ranks of men and women who come here. It is the work of ORRRC which is the starting point of these remarks today, which I believe may have relevance to our current environmental crisis.

In 1958, veteran conservationists such as Joe Penfold, Ira Gabrielson, president of the Wildlife Management Institute, and, of course, Pink Gutermuth, convinced Congress and the administration that a national study of outdoor recreation was timely and essential.

At their urging, Congress created ORRRC as a 15-member bipartisan group to study the nation's outdoor recreation needs. ORRRC was composed of four members of the Senate, two from each party, and four members of the House, again, two from each party. President Eisenhower appointed seven public members, including ORRRC's Chairman, Laurance S. Rockefeller.

The Commission submitted its report to President John F. Kennedy in January, 1962. That marked the beginning of a new era in outdoor recreation in America—and the beginning of something more. The Commission found that there were serious shortages in the nation's supply of outdoor recreation, particularly near metropolitan areas. It recommended actions to correct the situation.

Many of the Commission's recommendations were implemented by the Congress and by both Democratic and Republican administrations. The Land and Water Conservation Fund was created to assist federal agencies, states, and local governments to acquire recreation land. The Bureau of Outdoor Recreation (BOR) was established to provide national policy leadership and advocacy. National systems of wilderness, rivers, and trails were created. New federal initiatives were taken to provide outdoor recreation in crowded urban areas.

Most importantly of all, ORRRC brought about a public recognition that outdoor recreation is vitally important to American life. In doing that, ORRRC built a bridge between resources conservation and the developing new environmentalism. In many ways we have forgotten this important linkage. The prominence which environmental issues now receive sometimes obscures the work of the old conservation movement which laid the groundwork for sound land and water policy long before Earth Day.

On the 20th anniversary of the ORRRC report, a number of people and organizations suggested that there be a fresh look at what happened since ORRRC. They were motivated not by a desire to celebrate an anniversary, but rather by a deep concern over the changes in long-established programs which many felt had served the nation well.

These concerns came to focus on Laurance S. Rockefeller, the chairman of ORRRC. After receiving encouragement from the administration and Congressional leaders in the field, Mr. Rockefeller convened the Outdoor Recreation Resources Policy Review Group. Members were Emery Castle, president of Resources for the Future, Inc.; Sheldon Coleman, chairman of the Coleman Company, Inc.; William Penn Mott, president of the California State Parks Foundation and former state parks director; Patrick F. Noonan, former president of the Nature Conservancy, now president of Conservation Resources, Inc.; William K. Reilly, president of The Conservation Foundation, and myself as chairman. Though Mr. Rockefeller insisted on being listed as an "ex-officio" member, he attended all the meetings and was, in fact, the intellectual leader of the effort.

The Policy Review Group worked for four months, assisted by a three-person staff, a small group of consultants, and others who contributed to the effort. While the Policy Group's report is not a comprehensive study of the nation's outdoor recreation resources condition, it is an appraisal of the current situation by a group of individuals who know something about the field.

The Policy Review Group decided to address three questions:

1. What changes in demand for outdoor recreation have occurred over the past 20 years?
2. What changes in the supply of outdoor recreation have occurred?
3. What adjustments in the outdoor recreation system are needed to meet this new demand-supply equation?

We first looked at changes that had taken place in American society since ORRRC, and their implications for outdoor recreation. It is apparent that there have been profound changes in our society over the past two decades. Some were foreseen by ORRRC; others were not.

Some changes which ORRRC did see:

Our population continued to increase. Today there are 42-million more of us than there were in 1962, and although the rate of growth is slowing, the Census Bureau expects that we will continue to increase well into the next century.

In 1960, the majority of Americans lived in the Midwest and Northeast; today the bulk of the population lives in the West and South.

In the 1960s, metropolitan areas were growing rapidly with an influx of people from rural areas; today, small cities, rural towns and communities are growing faster than large cities. Within metropolitan areas, the suburbs are growing, while the central cities are losing people.

With a declining birthrate and advances in health, the nation is growing older; today the median age of the population is just over 30 years, compared to about 28 in 1967.

Generally, in spite of the bad times, we have more money, more discretionary time, and more personal mobility than we did in 1960.

And there are changes which ORRRC did not see coming.

Watergate, the assassination of national leaders, and the Vietnam conflict have left the nation more cynical about our collective ability, even our will, to solve difficult problems. We are far less trustful of institutions, both public and private.

Economic problems have led us to re-evaluate the capacity of government to respond to every social problem. There is a growing realization of a need for priorities, and to weigh carefully tradeoffs among programs.

The unprecedented gains of the 1960s and 1970s have now leveled off. Instead of a continually-expanding economy, we have an economy that only now seems to be pulling out of the deepest recession since the Great Depression.

The nation has been plagued with persistently high unemployment; now averaging over 10 percent, it disproportionately affects the young and ethnic minorities. As a result, some have become far less sanguine about work opportunities. There has been a change in attitudes toward jobs and a search for new avenues for personal satisfaction.

As individual aspirations and needs change, we look at our work differently. For many of us, what we do in our leisure time is becoming more important than what we do on the job. The trend toward job specialization, large organizations, and work that often is routine and dead-end has lessened opportunities for satisfaction in the workplace. This has led many to seek additional avenues of personal satisfaction in non-work activities—including recreation.

The role of women changed dramatically. Today, over half of the married women have employment outside the home. This is expected to increase to 61 percent by 1990. Working wives have been a major factor in the increase in family income. Single women now have more income, mobility, and appetite to use both.

Finally, though ORRRC sensed a strong public interest in environmental quality, it could not foresee that it would develop into a potent movement. When ORRRC was struggling for attention, it was incredible that environmental concerns would compete with foreign wars for page-one space in our daily newspapers.

The Policy Review Group next looked at what impact all these changes have had on outdoor recreation demand. Information on demand is not good. But, by every available indicator, it is increasing.

Visitation figures are up sharply. Participation has increased at a faster rate than ORRRC predicted it would. A surging interest in physical fitness is a major new force in the outdoor recreation picture. A recent study found that almost half of the adult population exercises on a regular basis, compared with 24 percent in 1960.

Spending is another indicator. Nationally, leisure expenditures have grown from $58-billion in 1965 to $244-billion in 1981. That's a 47 percent increase in inflation-adjusted dollars. Spending for leisure as a percentage of disposable income has also risen.

We then turned to supply. If demand for outdoor recreation is increasing, how does the supply relate to present demand and what might be expected in the future?

It is also difficult to get a good fix on supply. For one thing, supply undergoes constant changes as new recreation devices and equipment are developed. Further, information on the present supply of recreation land is very poor. Even basic information such as acres of land available for recreation use tells us little about the activities that take place on the land, or just how accessible the land is to potential users.

On the face of it, the nation has made remarkable progress in increasing the supply of publicly-owned outdoor recreation resources over the past two decades. The statistics are dramatic and important.

Through the Land and Water Conservation Fund, some 2.8 million acres of recreational land have been acquired by the federal government. Some 2.9 million acres were added to state park systems. Municipal governments added 1.7 million acres of non-urban park and recreation land, much of it with federal assistance. Nearly 80 million acres of wilderness are protected in the National Wilderness Preservation System. Almost 7,000 river miles have been incorporated in a National Wild and Scenic Rivers System. Some 680 trails, totalling more than 7,000 miles, have been incorporated in a National Trails System. The number of units in the National Park System has tripled, to 335 with 79.4 million acres.

This is impressive, but the use of the public lands has increased faster than we have added acres. While federal park and recreation acreage increased 3 percent over the past 20 years, use has increased 138 percent. For the National Park System, acreage inclusive of Alaska has increased by 5.5 million acres or about 28 percent since 1960. However, visitation grew 278 percent, from 79.2 million to just over 300 million. While the acreage in state park systems rose by 44 percent, visitation increased by 105 percent.

ORRRC pointed out that public land was scarce around populous metropolitan areas in the East. ORRRC urged that public land acquisition should emphasize what it termed "effective acres"—land where the people are. There has been some increase in acres of public land available for recreation, but there have been no significant increases in acreage per capita in the populous eastern states where ORRRC said recreation land was most urgently needed.

As a result of its examination, the Policy Review Group arrived at three fundamental conclusions and a recommendation.

First, outdoor recreation is more important in American life than ever. People value outdoor recreation in itself. In addition, the new interest in physical fitness and the acceptance of leisure as a goal have amplified the importance of outdoor recreation. Further, many of the concerns of the environmental movement are linked to the protection of outdoor recreation resources—in other words, environment. Clean water is essential for fishing and swimming, and dirty air obscures vistas at major national parks. Thus, fishable, swimmable water is a major goal of the Clean Water Act and protection of Class I areas of the Clean Air Act.

Second, in the face of increased demand for outdoor recreation, governments are doing less. At the federal level, expenditures peaked in 1978, and have fallen sharply. The Heritage Conservation and Recreation Service, the successor to BOR, has been dismantled. The Land and Water Conservation Fund has been sharply cut. Absent federal assistance, there is evidence that states and local governments also are reducing spending for outdoor recreation.

Third, the private sector is doing more, and could do yet more with government cooperation. Private recreation business has grown significantly over the past two decades, through the development of campgrounds, ski areas, and marinas; through the development of new equipment which facilitates public outdoor recreation activity; and through operation of facilities on public lands. Outdoor recreation is big business, and by creating jobs and attracting tourists, it is a major component of the nation's economy.

Private not-for-profit organizations also play an increasingly important role in outdoor recreation. Their growth has been phenomenal over the past 20 years. They encourage and help the donation of lands and capital to public agencies; manage lands and facilities on their lands for public use; maintain trails and hostels on public lands; and provide volunteer assistance to federal, state, and local recreation agencies.

On the basis of these conclusions, we feel there is a need to reassess the role of the federal government and other governmental and private sector providers of outdoor recreation. Perhaps government should do less. However, the dismantling of institutions and clear cutting of programs is not the answer. The Policy Review Group does not necessarily urge resuscitating old programs, but rather carefully thinking through alternatives.

The Policy Review Group recommended that Congress establish a new outdoor recreation resources review commission to conduct a review of outdoor recreation in America. We recommended that the new ORRRC be modeled after the original ORRRC—a 15-member commission comprised of eight members of Congress divided between House and Senate and Democrats and Republicans, and seven public members. We urge that the Commission have an independent staff and not have to rely on borrowed bureaucrats. We suggest that the Commission would work for 18 months and submit its report early in 1985.

While the new Commission would focus on outdoor recreation resources, we recognized that it must be given a broader mandate. The relationship of outdoor recreation with many indoor activities associated with physical fitness must be considered. A new study also must examine outdoor recreation in the context of the many uses of leisure time.

Outdoor recreation is a major goal of the Clean Water Act, the Clean Air Act, and other environmental legislation. Its relationship as a beneficiary and contributor to these programs should be looked at.

Legislation implementing the Policy Review Group's recommendation is now being considered by key members of the Senate and the House of Representatives. We hope that a bill will be introduced in the next few days and that the Congress will act upon it quickly. We believe it important that the new Commission begin its work this year and submit its report on schedule early in 1985.

I hope you will support that legislation and become part of the new ORRRC effort if it comes into being.

The past quarter century since ORRRC began has been a period of profound social, economic, and political change. The role of outdoor recreation has changed and, on its own and as part of the environmental and fitness movements, the ORRRC worked. We think a new ORRRC is needed to assess that role and help Americans enjoy its benefits.

Let me suggest that this new ORRRC might make an even more significant contribution.

Two decades ago, outdoor recreation served as a bridge between the old conservation and the new environmentalism. The values and programs of the old conservation were the foundation of the new environmental movement.

A bipartisan group with full Congressional participation which works as effectively and harmoniously as ORRRC did could provide a much-needed bridge between antagonistic interests which are threatening environmental progress in this country. A successful commission on outdoor recreation resources might be seen as a modest step, but as an example it could be a major stride back toward that bipartisan conservation-environmental consensus that has done so much for this nation's land, water, and air.

A new outdoor recreation resources review commission also could help build bridges of confidence among Congress, the Executive branch and the public. The original ORRRC was a successful example of citizens working with both the Executive and the Legislative branches of their government. From this effort grew mutual respect and confidence.

There must be confidence and respect if today's environmental problems are to be solved. The complex tasks of cleaning up water and air—and particularly toxic wastes—simply cannot be done in an atmosphere of rancor and confrontation. If every agreement must be fought out with the full array of legal proceedings that surround a criminal trial, our hazardous wastes will outlive us.

There must be a minimum threshold level of confidence and trust. To be sure, Congress must see that the laws they have enacted are faithfully executed, and the public has the right to know what's being done with its lungs and livers. But those in charge of the programs must have some latitude to carry out the public's business at the bargaining table, not the judge's bench or before Congressional committees.

However, this use of discretion must be won by administrators in the old-fashioned way—they must earn it. The confidence of the public and the Congress can only be earned by a record of decisions in the broad public interest.

A return to some of the principles of the old conservation, bipartisanship, trust and sound programs, will help the environmental movement today. The creation of an ORRRC, and even more importantly, the revitalization of the ORRRC spirit, would be one small step in this important direction.

Ecologists like to say that everything is connected to everything else. So it is good to be back at the North American Wildlife Conference to renew the connection. And perhaps we need to start around the circle again—the circle of sound conservation and environmental policies.

Retention of Federal (Public) Lands

The Honorable Ed Herschler
Governor of Wyoming
Cheyenne

It is a pleasure to address you this morning, and to provide you with my perspective on issues surrounding the privatization of federal lands. As you know, I am from Wyoming—and because of this, I possess an inherent western bias. You will recognize this bias as my presentation proceeds. I don't apologize for it. I am, in fact, rather proud of it—but it seems only fair to warn you in advance.

Public lands have always been the calling card of the West. From fur traders, to gold seekers, to ranchers and railroads, the availability of public land resources was the major stimulant of western development. Between the 1803 Louisiana Purchase and the 1867 Alaska Purchase, nearly 80 percent of the United States became federal property. Following that period of acquisition, and lasting until the 1930s, vast amounts of public lands were transferred to states, individuals, and corporations. In all, approximately 60 percent of the land originally owned by the federal government was disposed of through outright sales, homestead laws, railroad entitlements, irrigation and reclamation programs and other disposal initiatives. Everyone was following the advice of Will Rogers to buy land "because the good lord's not making any more of it."

These early initiatives were aimed at stimulating migration to and settlement of the western frontier. Once this goal was achieved, emphasis seemed to shift from disposal to retention and active management. The Taylor Grazing Act of 1934 was a response to an outcry by ranchers regarding the deteriorated condition of western grazing lands. This Act, for the first time, brought active federal management to the millions of acres of public domain lands that hadn't already been set aside and managed as forests, parks, or wildlife reserves. It also marked the end of the federal policy of public land disposal and the beginning of a policy of retention and management.

These retention and management policies have since been reinforced and refined by legislative action and judicial decisions. Actions such as the 1960 Multiple-Use Sustained-Yield Act, the 1970 Public Land Law Review Commission Report, the 1976 Federal Land Policy and Management Act, and the 1976 National Forest Management Act, clarified congressional public land policy. Three major points surfaced throughout this legislative debate. Those are: retention of public lands in federal ownership; multiple use management; and most recently, provisions for coordinated land use planning and public involvement.

Layered on top of this basic public land legislation is a mosaic of environmental and resource management legislation, including the 1969 National Environmental Policy Act, the 1964 Wilderness Act, the Mining Law of 1872, the 1971 Wild Horse and Burro Act, and a host of others. The courts have also gotten into the act with interpretations and rulings based on public trust doctrine precepts. These legislative and judicial actions reflect a national conviction that most public lands contain unique resource qualities, so essential to public or community well being, that they must be protected, managed, and made available primarily for public use and benefit.

With this evolution of national consciousness, it is easy to see why proposals for large scale disposal of public lands are met with widespread resistance. Nevertheless, such proposals have been pushed in the early 1960s, the late 1940s, the mid-1920s, and the late 1910s. The strongest support for public land disposals has come from historical users, mainly grazing and mining interests. Much of this support was in reaction to federal laws, regulations and bureaucracies, which restricted or controlled public land activities. After eight years as Wyoming's Governor, I can well attest to the frustrations of wrestling with many such Potomac creations.

The fact that the recent Sagebrush Rebellion followed closely on the heels of the 1976 Federal Land Management and Policy Act should be of no surprise to the student of public land history. However, while the Sagebrush Rebellion was an obvious gesture of western displeasure against Washington regulation, the unlikelihood of any legislative or judicial relief favorable to the cause tempered the public backlash. This was not the case with the Reagan Administration's "asset management" or "privatization" initiatives. Here, the outcry was immediate and vocal and apparently with some measure of success.

Disposal of federal real property and public lands through fair market sales with receipts earmarked for retirement of the public debt was first conceptualized in a senate resolution introduced in October, 1981 by Senator Percy from Illinois. This resolution called for an inventory of federal assets, estimation of value, determination of current and potential uses, sale of assets surplus to federal needs, and earmarking receipts to reduce the national debt.

On February 25, 1982, President Reagan signed an Executive Order which established a White House/Cabinet level Property Review Board. The purpose of this board is to develop and review all policy aspects of federal property acquisition, utilization, and disposal. The board is also charged with establishing annual target amounts of real property holdings to be identified as excess for disposal.

The administration unveiled the potential extent of the asset management program in its fiscal year 1983 budget. Budget documents projected receipts from sales of federal lands and buildings to total some $17-billion over a five-year period. The administration estimated that sales of Bureau of Land Management and Forest Service lands would return over $2-billion dollars annually beginning in FY-84. While Agriculture and Interior officials continued to downplay the need for major public land disposals, it soon became obvious these pronouncements don't track with the budget projections. The administration was suffering from the proverbial Washington disease of talking from both sides of its mouth.

In the summer of 1982, BLM identified 2.7-million acres of public land which had been targeted for disposal in existing land use plans. They identified another 1.7-million acres as potentially disposable under existing criteria, but requiring further investigation and plan amendments. The total estimated fair market value of both categories of acreage was set at $2.4-billion. This represented only one year's worth of the projected budget receipts.

Obviously, if public land sales receipts were to meet the objectives of the '83 budget, expanded disposal authorization would be necessary. This was particularly true with regard to national forest lands, where only 60,000 acres could be ultimately disposed of under existing sales authority. Likewise, the transition from existing disposal activities to those projected in the budget would be dramatic.

Total receipts from the BLM land sales program over the last seven years have been only $17.5-million. Now the administration was proposing to increase annual receipts almost 1,000-fold and sustain that level for four years!

As I said earlier, there were major inconsistencies between the budget projections and the administration's rhetoric. The estimated fair market values for BLM disposal parcels in Wyoming ranged from about $1,700 per acre near urbanized areas to $81 per acre for those parcels that are unconsolidated or uneconomical to manage. The statewide average was $217 per acre. If this average applied nationwide, the administration would have to sell about 10-million acres of public land annually to meet the 1983 budget targets. There are only so many Waikiki Beach and Las Vegas strip type parcels around. If these are disposed, the remaining lands are of much lower value, requiring large scale disposals to meet the original budget targets.

The administration's asset management plans raised serious concerns among governors of western states, where the federal government manages nearly 50 percent of the surface area. Several of us presented testimony at Senate and House oversight hearings. This testimony stressed the historic economic, social, and cultural ties which western communities have to the public lands. The lifestyle, wildlife, and heritage values associated with public lands resources were also highlighted. Likewise, the need to retain long-term productivity over the full spectrum of multiple uses was emphasized. Concerns over "suitcase landlords," access, hunting, fishing and other types of recreation were also voiced.

At my request, resolutions were adopted by the Western Governors' Conference, the Western Governors' Policy Office, and the National Governors' Association. These resolutions called for full consultation with state and local officials, public land users, and adjacent landowners prior to any disposal actions. They also served notice that we were opposed to disposals driven solely by the need to increase federal revenues. The resolutions spoke to the need to preserve community and economic stability, and prevent speculation or property devaluation. They also emphasized that disposal decisions must reflect a careful and planned consideration of wildlife and environmental values.

Many of these points have been reflected in other testimony and resolutions, such as the 1982 resolution adopted by the International Association of Fish and Wildlife Agencies. Official administration responses have been less than enlightening. They have ranged from "fact sheets" filled with rhetoric and "trust us" clauses to claims that asset management is no more than a new term applied to "routine" disposal actions.

I submit that increasing annual public land sales 1,000-fold is not a routine action, anymore than supply-side economics is a routine approach to government financing. I also submit that the supply-side approach to public land management is doomed to failure along with supply-side economics. The latter has resulted in massive budget deficits which may cripple economic recovery. The former could create a quality of life deficit from which the West, as we know it, could never recover.

Several political and economic observers claim that the Reagan Administration seized on supply-side economics as a theoretical base to launch their real agenda, that being the reduction of government. I suggest that the asset management initiative is a similar front. If asset management is driven only by the need to reduce the federal debt, the management side of the process is clearly a fraud. Utah's Governor, Scott Matheson, put it very aptly when he testified that we cannot accept a land sales program which replaces management needs with artificial budget targets in a cart before the horse fashion.

We in the West fully recognize that there are a variety of cases where public land disposals through sale or exchange are clearly in the public interest. We wholeheartedly supported Secretary Watt's Good Neighbor Program, aimed at the transfer of public lands needed for community expansion or recreation and public purposes. We are now dismayed to find that the Property Review Board has created another hurdle to Good Neighbor applications. Their policy of rejecting no-cost conveyances, and phasing out discount or low-cost conveyances, flies right in the face of Secretary Watt's good neighbor initiative. To be honest with you, I don't think he likes it one bit, but he is too much of a team player to object publicly.

Westerners can and do support disposal of public lands or transfer to state ownership in appropriate situations. However, we have significant vested interests in the management and use of public lands and we want our role to be commensurate with those interests. We worked long and hard to strengthen consultation and consistency requirements in federal land management statutes. To date, our drive to fully represent and protect our public land interests is best reflected in our water, energy, and wildlife management programs. The latter should be of particular interest to you.

The public lands comprise about 25 percent of the surface area of the United States. Yet, 45 percent of all who hunted in this country during 1980 did so on public lands. Well over 100-million days of hunting recreation were provided on the public domain in that year. In addition, nearly 22-million persons used the public lands for the primary purpose of observing and photographing wildlife during 1980, and an additional 49-million people indicated wildlife viewing opportunities as an important reason for visiting public lands.

It has been estimated that over 11.4-million recreation visitor days were spent on BLM lands in Wyoming in 1981. Wyoming ranks third among the ten western states in the amount of wildlife habitat under federal management. The state ranks first in the overall number of big game animals. Wyoming's public lands also support a diversity of nongame species, including the only known black-footed ferret population in North America.

There are 198 distinct herds of big game in Wyoming, including antelope, mule deer, elk, moose, bighorn sheep and mountain goat that rely all, or in part, on the public lands for their continued existence. These are free-roaming populations that migrate to and from ancestral seasonal ranges. Freedom of movement and maintenance of critical ranges, many of which are on the public domain, are essential to the health and vigor of these herds. For that matter, these lands are essential to the health and vigor of us all. The vast expanses of public domain are an integral part of the fabric of America. The wide-open West, to a great degree, defines this country, describing our concept of freedom and shaping our national personality. Disposal of these lands requires the closest scrutiny and the most careful consideration of the long-term ramifications of such a program.

In the words of the historian, Walter Prescott Webb, "The period of fusion in the American West is over, the loom is about full, the tapestry of an era is almost finished. The imagination cannot play anymore with the mystery and uncertainty of a half-known region, for there is no such thing. The map is finished, the roads surveyed."

I say the margin for error is now greatly reduced and decisions made today may be irrevocable. We must exercise great care that we do not trade long-term benefits for short-term gains—because there is no uncharted West remaining to which we can move.

As best as we can tell, the instigators of the administration's asset management program were economic and budget advisors within the White House and the Office of Management and Budget. The Property Review Board was their idea, not that of the federal land management agencies. These economists advanced many arguments supporting public land disposals. A major argument was that the public lands are mismanaged due to the lack of market incentives facing bureaucratic land managers. It was contended that lands in private ownership will be managed more efficiently and the output mix channeled to its maximum potential in response to market incentives and price demand signals.

While such arguments may track with economic theory, they do not bode well for wildlife and the many other non-commodity, non-market goods inherent on public lands. Quite often, the signals the private land manager responds to are of a short-term nature. The long-term productivity and multiple use potential of the land base often become secondary considerations or rejected outright if they conflict with short-term goals. The overall state of the economy also pressures private land manager decisions. Today's farmer, putting off soil conservation practices due to cash flow problems, is not acting with the interests of the land in mind. He is acting with self preservation in mind.

I personally don't think the administration's asset management program will wash with Congress; certainly not at the level originally envisioned. Indeed, there are obvious signs of retrenchment, such as the revised FY-84 budget targets of $300-million in BLM land sales and $200-million in Forest Service land sales, as opposed to last year's $2-billion target. Several of the staunchest privatization advocates have left the administration to carry their banner with groups such as the Heritage Foundation. They have turned to snipping at Interior and Agriculture officials for dragging their heels and frustrating the privatization agenda.

I'd like to believe that this retrenchment is a result of the outcry from state and local officials, Members of Congress, interest groups, and the public at large. This would indicate that our time honored system of representative government does indeed work. Nevertheless, until the veil of secrecy is pulled from the program and the issues and concerns resolved in an open, forthright manner, we must continue to press for information and answers. Until the right hand knows what the left hand is doing, we can't let a lack of coordination or ambidexterity fumble the national heritage embodied in our public lands.

Historical Perspectives on Water Management Policies and Procedures

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In 1975, some eight years ago, at a National Water Conference in Washington, D.C., I asserted that the "Federal water resources program is politically dying, if not already dead."[2] I then set forth my analysis of why this demise had occurred or was occurring.

Since 1975, in both the Carter and Reagan Administrations, more evidence has accumulated: no omnibus rivers and harbors authorizations for the Army Corps of Engineers (formerly a regular two-year occurrence) have been enacted and no new authorizations for the Bureau of Reclamation have been made, except for a very few exceptions.

Before 1975, the Bureau of Reclamation had no significant new authorizations since the Colorado Basin Projects Act of 1968, which authorized the Central Arizona Project and a few other projects. From 1950 through 1980 the constant dollar average authorizations for the Corps of Engineers by each Congress (a two-year period) was about $3.1 billion. The last Congress to exceed the average authorization level was in 1968. "The absence of an 'average' congressional authorization since that time is clear evidence of a decline in the Corps' role in water resources development as measured by project authorizations."[3] As measured by constant dollar appropriations, "the lowest average five-year average for [the thirty-year] period occurred from 1975 through 1979 when construction appropriations averaged $1.9 billion."[4]

With the foregoing assertion and data as background, I now propose to set forth briefly:

First, why the Federal government got into the water resources development business at all;

Second, why it is getting out now, with certain specific exceptions;

Third, alternatives for future water resource development, as: (a) proposed by the Carter and Reagan Administrations and (b) suggested by me to the Reagan Administration;

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[2]Henry P. Caulfield, Jr., "Let's Dismantle (Largely but not fully) the Federal Water Development Establishment, or the Apostasy of a Longstanding Water Development Federalist," in the *Proceedings of the National Conference on Water,* Washington, D.C., April 1975, sponsored by the U.S. Water Resources Council (Washington, D.C.: U.S. Government Printing Office, 1976; Stock Number 024-001-02798-4), pp. 180–184.

[3]Charles Yoe, *The Declining Role of the U.S. Army Corps of Engineers in the Development of the Nation's Water Resources* (Colorado Water Resources Research Institute, Colorado State University, Fort Collins, Colorado 80523; Information Series No. 46: August 1981), p. 115.

[4]Yoe, p. 86.

And fourth, the implications of these alternatives for individuals and groups associated with the North American Wildlife Conference in the assertion of their concerns in further water resources development.

Why Federal Water Resources Development

Very early in the nineteenth century, the principal port cities along the Atlantic coast (particularly Boston, New York, Philadelphia, Baltimore, Washington, and Charleston), in cooperation with private business interests, became rivals in development of inland commerce to the West through making river navigation improvements and constructing canals and portage facilities over mountains. The period between 1817 and 1838, known to historians as the Canal Era, means the period when state governments took the leadership role in developing inland navigation projects with the support of cities and in cooperation with private enterprise. Some Federal assistance was given in the form of public-land grants and army surveying personnel.

Failure of state and private enterprise during the Canal Era (due largely to inadequate financial and technical resources); the strong belief of the new Republican Party in Federal constitutional power; the conviction that development of inland navigation to provide cheap transport of agricultural and other commodities was a key national public means to encourage economic development of the West (the humid West, that is); the availability of financial resources brought about by import tariffs; and the available technical skills of the Army Corps of Engineers—all resulted in Federal assumption after 1860 of responsibility for planning, financing, construction, operation and maintenance of inland navigation by the Army Corps of Engineers.

In the latter half of the nineteenth century, in the arid West, private, cooperative and local public enterprise undertood construction of diversion, canal, and storage works to provide water for irrigated farming. Before the century ended, local enterprise in the front range of Colorado went beyond works to divert and convey water from the South Platte and its tributaries. Collection works high up on the west slope of the Rocky Mountains, with transbasin conveyances to the east slope, were constructed to supplement river flows. In Utah, Arizona, Idaho, California and in other states of the arid West, local irrigation development also occurred.

Again, provision of greater technical competence and longer term financial capital was perceived in Washington as key National public means to foster settlement and economic development of the arid West via greater irrigation development. This perception led politically to assumption of Federal irrigation development responsibilities via the Reclamation Act of 1902.

These assumptions of Federal responsibility for inland navigation and irrigation developments need to be seen too in a wider political context. From the earliest years of the Republic, occupation and military defense of the lands claimed and acquired West of the original Eastern state boundaries were a major National political preoccupation. Great Britain, France, Spain, and Mexico were seen as rivals in quest for the land which became the United States. The comprehensive inland navigation plan of Secretary of the Treasury Gallatin in his *Report on Roads and Canals* of 1808 had, as its stated goals, economic development, furthering political unity and military defense.

After the advent to power of the Republican Party, the navigation program of the Army Corps of Engineers furthered these political goals in the humid East and Midwest. The more specific objective of enabling cheap bulk transport of grain from the Midwest to East Coast and international ports was seen, especially, to be in the national public interest.

The Reclamation Act of 1902 was a logical specific means of furthering the National political objectives of settlement and economic development, as applied to the undeveloped arid West. Toward the end of the nineteenth century, gold, silver, and other mining was petering out in Nevada and elsewhere. However, extensive grazing of cattle was flourishing. Nevertheless, more irrigated agriculture was then seen by Senator Newlands of Nevada and other leading proponents of the Reclamation Act of 1902 as a national strategic instrument to further settlement and economic development of the arid West. At the time of its enactment, the Reclamation Act was not justified by argument that more agriculture commodities were needed. There were then no general food shortages. In fact, Midwest farmers saw increased production of western farmers as depressing prices further that were already seen to be too low; and they opposed the Reclamation Act.

In summary, the assumption of Federal responsibility for internal navigation and irrigation developments was politically animated by widely held broad national goals of settlement and development of the West and by practical considerations of finance and efficient provision of scarce technical competence. All water resources development was not taken over by the Federal government from the states and local governments; both municipal water supply and flood control responsibilities were not changed. The only water functions then changed were those politically seen to be useful instruments of broad National political purposes.

The Conservation Movement, which became a national political force early in the twentieth century (through the leadership of Theodore Roosevelt, Gifford Pinchot, John Wesley Powell, and others) fully supported national economic development through Federal water resources developments as well as non-Federal developments through license under the Water Power Act of 1920. The Conservation Movement articulated the concept and need for comprehensive multiple-purpose river basin planning and development throughout the Nation. The first such comprehensive plan was undertaken for the Colorado River. This plan led to the Colorado River Compact of 1922, the Boulder Canyon Project Act of 1928, and subsequent projects. In a larger National perspective, Section 308 of the Rivers and Harbor Act of 1927 called upon the Army Corps of Engineers to develop comprehensive multiple-purpose river basin plans for all the major river basins of the United States. Multiple purposes at that time meant navigation, irrigation, hydroelectric power, and flood control.

Many of the "308" plans, calling for construction of large multiple-purpose dams, were completed by the beginning of the Great Depression of the 1930s. Policies to overcome the depression provided the Federal financial means for large public work projects. Where regional political support for water resource development was also present, great Federal developments began, for example, as on the Tennessee and Columbia Rivers and in the Central Valley of California (by the U.S. Bureau of Reclamation). Where regional political support was denied, for example, on the Connecticut and Potomac Rivers, development did not occur, despite the availability of both plans and funds. Nevertheless, the Federal big dam era prevailed in much of the country, but particularly in the South and West, well into the 1960s.

On the level of broad political purpose and political visibility, river basin regions substituted for "The West" as the geographic object of economic development. Geographic regions, like the ten-state Missouri basin, became political aggregates in support of Federal development.

Municipal and industrial water supply, recreation and fish wildlife enhancement later became authorized purposes of multiple-purpose dams. On the ideological level, water resource developments could thus be seen as more fully utilizing natural resources; and, on the political level, new constituencies were added in support of water projects.

Much of the most aggressive political support for the Federal big dam era came from the South and the West and, particularly, from political supporters of Federal public power with preference in the distribution of power of public bodies and rural electric cooperatives. Much political support also was provided by the proponents of navigation, irrigation, and flood control through the lobbying efforts of the National River and Harbors Congress (formed in 1902) and the National Reclamation Association. Membership, particularly that of the former, included large numbers of members of both the House of Representatives and the Senate. Before lobbying the Executive Branch and the Congress for water resource developments, these organizations regularly performed the necessary political function of prioritizing potential authorizations and funds for "new starts" on the basis of geographic and other distributive factors acceptable to their members.

At the beginning of the 1960s, National political leaders called for renewal of water resource development. The bi-partisan Senate Select Committee on National Water Problems unanimously called upon the Executive Branch to undertake a new era of comprehensive river basin plans on all the major river basins of the United States. President Kennedy immediately accepted the goal of completing these plans by 1970. Moreover, he repudiated the alleged "no new starts" policy of the Eisenhower Administration and reestablished administrative policies favorable to public and cooperative electric power. At both the political and technical level, it was assumed that much water resource development still needed to be accomplished and that the political support needed to get it done was widespread and strong. These assumptions proved, increasingly, to be false as the years passed to the advent of the Carter Administration in 1977. The decline in this Federal function became increasingly evident.

Why Federal Government Largely Getting Out

In 1962, preservation in their natural condition of particular rivers, or segments of rivers, was authorized for planning within the Federal government, and, in 1968, Congress passed the Wild and Scenic River Act authorizing establishment of eight wild or scenic rivers and the study of twenty-seven more. These actions were taken within the context of what became the Water Resources Planning Act of 1965. Under this act, it was assumed by Federal policy and planning officials that only particular rivers or segments, not all rivers, would be preserved and removed from the possibilities of multiple-purpose development. However, with passage of the Wild and Scenic River Act and other manifestations of the Environmental

Movement (particularly passage of the National Environmental Policy Act of 1969), the most far out environmentalists adopted the view that dams and reservoirs could never be justified for any purpose. As a consequence, the Environmental Movement, composed largely of urban political activists, succeeded in stopping many water resource developments and in authorizing many wild and scenic river proposals.

Also, since the mid-1960s, the futility of reservoir storage as the primary means of flood control had become widely recognized. "Non-structural" measures such as flood insurance, floodplain zoning, warning systems, flood-proofing, etc., came to be seen as the most appropriate means to be employed in flood hazard mitigation. And most of these measures require largely state and local (not Federal) nonstructural implementation.

Decline in Federal dominance in water resources development also was fostered by Federal policy. Implementation of Title II of the Water Resources Planning Act of 1965, which authorized establishment of Federal-state river basins commissions, encouraged states to share responsibility. Even more directly, implementation of Title III, which authorized 50 percent matching financial grants to states to encourage them to undertake comprehensive water resources planning, increased state professional capability to undertake greater responsibility. Increased state professional capability also has been fostered by the Water Resources Research Act of 1964, as amended and supplemented, under which water research institutes have been established at each state land-grant university.

With the achievement of multi-faceted economic development throughout the country, water resource development can no longer be cited as the "key" National public means of encouraging general economic development. It has lost its traditional, National ideological relevance. Moreover, major resource basin developments had largely been accomplished on the Columbia, Colorado, Missouri, Ohio, Tennessee, Mississippi, Arkansas and Rio Grande Rivers. The pro-development lobby groups markedly declined in constituent support and in effect. The public and cooperative power groups almost completely lost interest. Majority votes in the Congress for water projects, East and West, which were increasingly hard to put together before the Carter Administration, have been much more so since 1977.[5]

Finally, among the interrelated factors that help to explain the decline in political support of water resource development projects is the political emergence of a national urban majority. Agriculture and other resource development concerns are not a major interest of this relatively new national majority; they are foreign to it.

In the area of domestic policy, the urban majority is primarily concerned with urban problems: housing, transportation, health, welfare, air and water pollution, urban open space and recreation areas, energy, etc. Its concern with the rural and natural hinterland, expressed effectively now for some 15 or more years, is that of the Environmental Movement. Urban people, not rural people, strongly support

[5]See Yoe, pp. 122–155 for congressional vote analyses. These analyses do not support this conclusion. Nevertheless, general observation of the increasing difficulties encountered in creating majorities would seem to support this conclusion. Explicit studies, however, are needed.

establishment of wilderness areas, national parks, wild and scenic rivers, and fish and wildlife enhancement.

The Federal response to urban problems has not been a federalist response of direct public service such as that of the Corps of Engineers and the Bureau of Reclamation. The Federal response has been categorical financial grants-in-aid to state and local governments and, more recently, block grants and general revenue sharing.

Alternatives for the Future

The Carter "hit list," developed by ardent environmentalists within the Administration, clearly poisoned the atmosphere for negotiation of policy change. Economists within the Administration, in agreement with environmentalists, were able to so tighten the Principles and Standards of the Water Resources Council (WRC), and their related procedural manuals, that economic justification of almost any water resource development project, but especially an irrigation project, would be next to impossible. This action, when combined with the President's proposal that all proposed Federal water resource projects be subject to review by the WRC, made fruitless any attempt by Congress to reach agreement with the Carter Administration on U.S. water resources policy.

The only policy proposal of the Carter Administration that appears to be having some carryover value to the Reagan Administration is the Federal-State financing proposal. This called for states to supply 10 percent of the front-end funds for projects with vendible outputs and 5 percent of the front-end funds for those without vendible outputs.[6]

The Reagan Administration came into office with the solid support of the Western states, where water projects still have great political symbolic importance. The chairman of the Administration's water policy task force is William Gianelli, the former director of the California Department of Water Resources (which implemented the state's own $2-billion water resource development plan). The Administration soon indicated its desire to abolish the WRC and to rescind the WRC's Principles and Standards and related procedural manuals in their entirety. It has dismissed the entire staff of the Water Resources Council, abolished all the Federal-state river basin commissions created under Title II of the Water Resources Planning Act of 1965, and has succeeded in stopping the 50 percent grants to states under Title III.

New "principles and guidelines" are still in the process of adoption. Substantial differences apparently have been encountered in their preparation, review, and acceptance.[7] The Reagan Administration not only includes officials who believe fundamentally in water resources development, like Mr. Gianelli, but also economists who are even stricter constructionists in their principles of benefit-cost analyses than the economists of the Carter Administration.

Also, internal consideration of up-front-financing and cost-sharing policy has taken many months, with Presidential policy announcement reported to be sched-

[6]President Carter's Message to Congress on Water Policy, June 6, 1978.
[7]These are not "rules" enforceable by Federal Courts, as were the Principles, Standards and Procedures of the Carter Administration.

uled now for April 15. As of now, the Administration appears to be pointing generally towards a 35 percent cost-sharing and financing arrangement with non-federal interests, except for hydroelectric power and municipal industrial water for which 100 percent will be required and special provision for navigation improvements. This possible arrangement, of course, provides for substantially greater non-federal cost-sharing and financing than that proposed by the Carter Administration. Mr. Gianelli, in his presentation at this Conference, will, no doubt, speak as definitively, as he now can, on Administration cost-sharing and financing policy.

Despite their differences, one point is now abundantly clear: both the Carter and Reagan Administrations have assumed that the key that will unlock the door politically for appropriate Federal water projects of the Army Corps of Engineers and the Bureau of Reclamation is up-front-financial and cost-sharing with states, local governments, and private interests. Both have ignored the fact that the old political epithet of "pork barrel" now appears to signify widely within the public, particularly in the East, that no Federal water project is ever valid. Both have ignored the more fundamental National political factors, discussed above, which would appear to be important regardless of reform in up-front-financial and cost-sharing policies.

Instead of continuing along this line, why does not the Reagan Administration jettison much of the Federal water resources development program as manifestation of its New Federalism and take widespread political credit for abolishing "pork barrel?" Its 1980 campaign commitment in the West to favor Federal water projects could be one reason. But with skillful preparatory work and leadership, this hurdle surely could overcome.

I recommend that it propose a block-grant to states in aid of both intra-state water supply and water quality investments by state and local governments and place clear responsibility upon them and their local governments to solve intra-state water problems. The financial grant could take the place of the present elements of non-reimbursable investment in Federal water projects. Also, it could take the place of the Federal grant program in connection with public sewage treatment projects. Finally, it could be used by states to meet a wider array of needs than can be met by traditional Federal projects: by rehabilitation of urban and rural water supply systems; rehabilitation of old irrigation projects; by funding to meet present-day standards of dam safety and by interconnecting of water systems to facilitate transfers of water rights.

No doubt there would be problems making a legal distinction between intra-state and interstate responsibilities, with the Federal government clearly needing to retain responsibility for the Nation's 25,000 miles of inland navigation system, flood control relative to the Lower Mississippi, and other major interstate developments. No doubt also there would be a difficult problem of devising a formula for allocation of the block-grants among the states. But this political and technical problem, in principle, is no more difficult of solution than it has already been for the highway program, community development block-grant, the social services block-grant, and others.

States and local governments, with their own staff as supplemented by private engineering organizations, are certainly technically capable of replacing staff of the Bureau of Reclamation and the Corps of Engineers. Also, state and local governments generally have authority (but differ somewhat among them) to finance investment costs by revenue and general obligation bonds, particularly where repayments can be met efficiently by user changes and property taxes. Financial aid via Federal block-grant is often needed where investment costs cannot be so met (e.g., recreation and enhancement of fish and wildlife).

This concept of partnership between Federal, state, and local governments appears to me to be more politically feasible than the partnership proposal, involving continuation of Federal projects to meet intra-state needs, that apparently is now being developed within the Reagan Administration. Certainly, it would implement more fully the Administration's philosophy of New Federalism. Moreover, states like Colorado, Wyoming, Montana, and no doubt others have already taken major steps to assume financial and technical responsibility for water projects themselves if the financial and other terms of proposed partnership with the Federal government are not to their liking.

Implications for Constituents of North American Wildlife Conference

Even if intra-state Federal projects on terms acceptable to states become Administration and congressional policy, Administration officials have made clear that much of the responsibility for deciding what projects would be built will rest with the states and local governments. This locus of responsibility would, of course, be even greater under a policy of state and local projects aided by Federal block-grants.

This change in the locus of major decision responsibility and control has very substantial implications for individuals and groups who identify with the North American Wildlife Conference. No longer would you be able to focus effectively your concerns with water resources development projects on the Federal government alone, largely in Washington, D.C. You would have to decentralize your organizations to express your concerns state by state. This would mean very substantial reorganization and change in your customary procedures. Nevertheless, I believe you should welcome this probable change. It would enable you to develop better organized and informed groups at state and local levels to express your concerns. Inasmuch as most big water resources development projects are of the past, you would need to identify your concerns with respect to a widespread array of much smaller projects. You will need to relate to other local water interests to find, if possible, mutually acceptable water plans. You will need to express your views more effectively than in the past to both local and state governments. And you would need to be more concerned than in the past with capabilities and funding of state fish, game, and recreation agencies.

Again, I say you should welcome this probable change and view it as an opportunity: an opportunity to strengthen your very valid environmental concerns within the whole cultural and political fabric of American society from the grassroots on up. The desperate attempts to play the game of water resources politics effectively in Washington would become decreasingly necessary. And, in the long-term future, your environmental concerns would become more widely the concerns of the American people and thus more secure.

Current Initiatives in Water Management Policies and Procedures

Robert K. Dawson
Deputy Assistant Secretary of the Army (Civil Works)
Washington, D.C.

It is a pleasure and an honor to be here at your 48th annual conference. Your program is very ambitious. I know it will be very valuable judging from the timely and critically important discussion topics.

I bring you greetings from Bill Gianelli, Assistant Secretary of the Army for Civil Works, who, over his 40-year career as a practicing engineer and in state government has spent a great deal of time working with associations like yours. Mr. Gianelli would be with you today were it not for testimony obligations on Capitol Hill. He and I are kept abreast of your concerns by Larry Jahn, the fine vice-president of the Wildlife Management Institute. I should note, too, that Larry is expanding his public service by serving as Chairman of the Environmental Advisory Board, the board set up to advise the U.S. Army Corps of Engineers on environmental matters. In this capacity, we look forward to continuing to work closely with Larry.

Our office provides the civilian leadership to the civil works arm of the Corps of Engineers. No doubt many of you have worked closely with the Corps to mutual benefit. Through its water projects, the Corps has long been involved with fisheries resources. Nationwide, there were about 470-million visitor days at Corps' projects in 1981. This is nearly two days for every person in the United States. Most visitors were involved in water related activities and many were fishermen.

Corps' projects enhance fish production in many cases. For example, water quality management at Libby Dam, Montana, has changed the character of a 20-mile stretch of the Kootenai River from a mediocre trout fishing stream to one of "Blue Ribbon" quality. The Corps has constructed many fish hatcheries at its projects and many others have been built because the Corps' projects provide the needed environment.

The operation of Corps' projects is often modified to enhance fish and wildlife resources. Where Corps' projects do cause substantial loss of fishery resources, the Corps often develops plans to offset the loss and even enhance the resource. For example, the Lower Snake River fish and wildlife compensation plan is a $140-million plan to mitigate losses due to the Lower Snake River Dam. It will produce 27-million juvenile salmon and steelhead annually and will provide 750,000 angler days of recreation each year. This is but one instance of the Army's concern for fish and wildlife resources.

I don't have to tell you that we are in a period where changes confront those involved with water resources. We are faced with new economic realities and new political circumstances which mean that the former way of doing business in water resources will not work in the foreseeable future. Estimates have been made that as much as $20-billion dollars need to be invested in water projects in the coming decade to solve problems that have been identified. So, we are facing continued demand for ever better utilization of our valuable water resources in an environmentally acceptable manner.

The economic reality that we face most vividly is the federal budget crunch and the fact that dollars for water projects cannot come from the federal treasury if we expect to get our country back on a sound budgetary footing. This reality is now, I am sure, appreciated throughout our country. In short, we absolutely must base our programs on good, sound investment practices with less burden on the federal taxpayer and with greater reliance on the willingness of project beneficiaries to pay to measure the merits of a project.

So let me go on to address some of the things the Reagan Administration is doing in view of these new realities. First, a determined effort is being made to identify what the federal interest really is in various water projects. We believe that the contribution of projects to the nation's economic development is a key feature in establishing the federal interest in water projects. We also believe that the advice and participation of state and local governments will be excellent guides in determining what are genuinely national concerns. Consultation with groups such as yours will assure that environmental safeguards are considered.

At the same time, we are addressing what is *not* the federal interest. For example, water projects with only local or regional beneficiaries may not qualify as they have in the past for federal financial support. But, we are firmly committed to the use of federal expertise in the planning and construction of these water projects if that is the most efficient way to get the job done *and* if the non-federal sponsors so desire.

Projects with single-purpose water supply benefits, water distribution and systems rehabilitation seem to be the areas where entities other than the federal government should take the lead. Also, single-purpose hydropower projects, it seems to us, can often be developed by non-federal interests without drawing on the federal budget.

Our next approach to these new realities is to insure that our federal water projects are both economically and technically efficient and environmentally sound. One way we see to promote efficiency in water resources development is through the new planning guidelines which the President has recently signed. In the future, when the Corps of Engineers undertakes new studies of individual projects, as directed by the Congress and the President, we believe it should be done in two stages: A 100 percent federally-financed reconnaissance study lasting perhaps 12 to 18 months. Then, if the reconnaissance study is favorable, it would be followed by a feasibility study which would be cost-shared 50–50 between the federal government and the project sponsors.

It is time to face the fact that only when a study results in the solution of a real water problem—in a project being constructed—can we say the study is successful. We have spent too much money, over too many years, not to give this new approach a chance. We are convinced that this approach will result in identifying those projects that have the best chance of ultimately being financed and constructed.

We also have been examining new formulae for cost-sharing on various types of federal water projects. Where project services are clearly marketable, such as municipal and industrial water supply, and power output, our cost-sharing policies will be quite straightforward. We believe that the project beneficiaries should repay all construction costs and all operation and maintenance costs.

For other project services, such as flood damage reduction and recreation, defining the proper division between federal and non-federal responsibilities is not so clear. In any event, creative application of the concept of "user pays" will remain fundamental to obtaining administration support for proposed federal water projects.

Requiring repayment of project costs by the beneficiaries is a sure way of testing the merits of a project. We must keep in mind though, that repayments over an extended time as opposed to at least some up-front non-federal financing, do nothing to relieve the current pressures on the federal budget. Accordingly, we are addressing a range of new approaches to the business of up-front financing of federal water projects. In our review of Corps of Engineers' projects to be considered for possible new starts, we are putting top priority on those where net economic benefits are greatest and where potential exists for a non-federal participant to come forward with an innovative financing proposal.

An example of the concept that we think could be applied to federal projects is the way a California water project was approached under Secretary Gianelli's leadership. When he was the water resources director under then-governor Reagan, they were able, with a project costing well over a billion dollars, through sale of revenue bonds based upon contracts, to repay the costs of power and, by other marketable outputs, to finance the project without imposing a tax burden on citizens of the state. While the experience on that project may not necessarily be an exact model for future federal water projects, we believe that the concept can be applied to many proposed federal projects to relieve the burden on the federal taxpayers.

Our present approach to new project starts includes a series of meetings, held in the past year throughout the country with local project sponsors, to explore their capability and interest in working out new financing arrangements. Our proposals have been received with considerable interest and the spirit of willingness on the part of non-federal sponsors gives us great confidence that many of the Corps' proposed new starts can be developed with substantially more financing by local sponsors than has been in the past. We believe our cost-sharing proposals warrant your support and will go a long way to getting rid of the "pork barrel projects" we've seen in the past. Our future successes in planning good water projects will be measured by the extent of participation by the non-federal entity in developing alternatives, identifying marketable features, and participating in viable, acceptable financing arrangements. I see this federal–non-federal partnership between planners and developers to be perhaps one of the most important features in the future success of our program.

Let me go on to mention another new area in which you are interested. Under the President's regulatory reform effort, we have been examining the Corps of Engineers' regulatory program in depth looking for ways to streamline the process without diminishing environmental safeguards. We want to focus our limited manpower on truly important areas.

In January 1982, an interagency working group, which included the departments of the Interior, Commerce, Agriculture, Justice, and Transportation, and EPA, CEQ and OMB, submitted recommendations for needed reforms of the Corps' regulatory program to the presidential task force on regulatory relief, headed by Vice-President Bush. In May, 1982, the Presidential Task Force directed that we and other federal agencies proceed to implement the reform measures. Briefly, we were directed to:

1. Develop new agreements with the federal resources agencies to assure that disagreements over permit decisions are resolved in less than 120 days compared to the then-existing arrangement, which could take several years.
2. Modify our internal procedures so that in most cases the District Engineer makes a decision on an application within 60 days. Extension to the comment period will be granted when necessary to insure compliance with the law.
3. Expand the use of general permits to minimize paperwork and reduce duplication, when environmental protections are not diminished in the process.
4. Give the states more authority and responsibility by issuing general permits to avoid duplication of good programs in those states whose environmental and regulatory programs are substantially similar to those of the Corps; and by EPA's revision of its regulations to provide increased incentives and simplified procedures for state assumption of the Section 404 Program.
5. Recognizing that the jurisdiction of the Corps' regulatory program should not encompass all biological wetlands, we will try to redefine the scope of the program to introduce a reasonable degree of certainty, while maintaining essential protection of the integrity of the nation's waters.

Last July, we published new regulations to govern the permit program. These contain many measures to shorten processing times as well as provisions for increased use of general permits, which allow certain activities to proceed without the need for an individual permit and to reduce duplication of effort with other levels of government.

These regulations were proposed under the previous administration, and we allowed them to proceed because we felt they provided significant reform to the regulatory process while still maintaining the environmental protections established by law. As you may know, these regulations are being challenged in court. We feel that sufficient environmental safeguards are engineered into each reform feature and that the court will come down on the side of good government. These measures and others will be healthy steps in the direction of good government and will provide the regulated public with a responsive and sensible program that will allow needed development to proceed and still protect our important natural resources.

We may collectively agree that many waters and wetlands are biologically important and need to be protected. Unfortunately, we do not have the tools to achieve the needed protection. The Clean Water Act is oriented toward water quality and is not adequate to protect wetlands from destruction other than by covering with dredged or fill material. For example, wetlands can be destroyed by draining, flooding, clearing and excavation, normally without the need for a Corps' permit. We feel that Congress should look closely at this situation and consider an appropriate remedy. We support the so-called POWDR initiative by Secretary Watt praised by Dan Poole.

I was pleased to note in a recent *New York Times* article that some are not waiting for the Congress to act. The 31-year-old Nature Conservancy has developed a new national wetlands conservation project to acquire critical wetlands with the help of business, government and private philanthropy. The Mellon Foundation has contributed $25-million to this project. We feel that this approach, which completely protects valuable wetlands—some of which are very hard to manage by any government entity—from development, is a good way to go.

These were the main thoughts that I wanted to bring to you with a hope of stimulating your thinking today. It seems to me that the federal water resources business is at a crossroads. Clearly, old ways of doing business will no longer work, and it seems to me also that 1983 must be a year for enacting new concepts that will allow needed development to proceed, but only with adequate regard for our natural resources. I encourage you to continue working with us and the Corps. Your role as advisor and environmental conscience is vital to the wise use of our waters. We cannot allow our economic recovery to stall, but we also must keep in mind our precious natural resources. Together, we will achieve the proper balance.

Approaches for Resolving Mid-America's Farmland Problems

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It is bad manners to come a guest to the Wildlife Conference and first off question the rules of the game. I must, however, quibble with the title assigned me; to answer that question requires only one word: people. From the eroded piedmont of the Carolinas, to the exploited loess hill of Iowa, to the ravaged sandhills of Nebraska, to the crumbling palisades of California, farmland has only one "problem," and it is people—greedy people, uninformed people, heedless people. Topography and climate alter the forms of exploitation, but the exploiter is universal, that sentient being who is steward of the earth's resources. The constraints to action are our handicap; insensitivity to a conservation ethic is our threat.

If soil erosion is controlled to assure sustenance for posterity, it will be because those who own and operate the land are motivated to conserve. There is proven technology, appropriate to varying circumstances, to bring to T every acre of soil this nation needs. Here, we must concern ourselves with the constraints to proper management of soil and water. Motivation is the pervasive constraint; there is no lack of information or expertise; there is tragic lack of motivation. A significant body of our tax laws, our public policies, and our economic incentives are those of a young nation promoting exploitation rather than those of mature nation perpetuating civilization.

If we hold the purpose to conceive a sustainable society, it is sophistry to explore the sciences of soil and water management, without injecting the motivations which will implement knowledge. Any nation which expends a suicidal disproportion of its time, money, and natural resources on systems designed to blow up the planet, has not faced reality. Our soil and water may last as long as humans do, without our intervention, unless society makes painful choices and allocates its natural and human resources to peaceful resolution of the stresses arising from irresponsibly increasing the numbers of the human species using this finite planet.

Only a conservation ethic based on acknowledgment of the source of our wealth can offer that protection for our farmlands which will bequeath them a heritage to our posterity. We must comprehend that basic wealth does not "trickle down" in spite of the bungling of bureaucracy, but "percolates up" from the earth by our labor. Products of the soil, the waters and the mines are the only source of real wealth.

Mitigation of soil erosion and protection of water supply is not the primary, nor even a principal thrust of our current laws and government policies. The position of this administration, poised between hostility and indifference, is only slightly more inimical than that of most government. In an editorial in the April, 1982, *Saturday Review,* Norman Cousins laments that legislators give little serious attention to the effects which legislation may have more than 4 years ahead. He says, "Very little of (the legislation) anticipates the fundamental needs of the nation in the years ahead. There appears to be a four-year fence that blocks the view."

Historically, price support programs have rewarded the farmer exploiting the land and penalized the farmer with a good conservation program in place. The unfolding PIK program may by its very improvisations prove to be an exception. Tax laws are fueling conversion of good rangeland to poor farm land. Those of us who remember the Dirty Thirties may have yet to see the *great* Dust Bowl. Investment credit rewards the purchase of bigger equipment which disturbs more ground faster and fits less conveniently into contours and terraces.

The traditional tax deduction for children lingers from a time when infant mortality was high and when seemingly limitless frontier beckoned for settlement. Implicitly, it favors more pressure on the land. Proliferation of population is the obverse of nuclear proliferation as a threat to the species.

In the 1970s, when the bins were emptied by a stroke of luck, farmers were admonished to plow and plant to feed a hungry world. Then, embargo and talk of embargo from politicians incapable of handling a politico-economic crisis in a statesmanlike manner, scuttled farmers' credibility as suppliers. In the cost-price squeeze thus created, the only recourse for the beleaguered farmer was to become more efficient, harvesting a sea of unmarketable grain at a morally indefensible cost to the soil and water inventory.

Production must be controlled. Excess food, feed, and fiber is waste. To afford the long-range investment that is conservation, we must have a profitable agriculture. A wasteful agriculture cannot be profitable. We farmers did not make enough money in 1982 to service our debt of over $215-billion. The estimated 1982 farm income of $18-billion will not even pay the interest. During 1982, farmers' equity in their holdings fell by $35-billion, the steepest drop recorded by USDA. We cannot provide all the food for a hungry world, nor do I believe that we should ravage our non-renewable resources in trying to do so. Rather, we should offer our finest technology, our expertise, and in some circumstances financial guarantees to help developing countries grow food, feed, and fiber suited to their specific needs.

The eminent, but controversial biologist, Garrett Hardin gives this example of harm done by well-meaning donations of food: "Those 1,000,000 who are hungry are reproducing. We send food to *them* (1,010,000). *Their* lives are saved. But since the environment is still essentially the same, the next year they (1,030,000) ask for more food. . . . it is a growing disaster, not a passing state of affairs." With his horror of unrestrained human population growth, Hardin has coined the aphorism, "Thou shalt not violate carrying capacity." or more broadly, "For posterity's sake, we should never send food to any population that is beyond the realistic carrying capacity of its land", quoting from a review in *Atlantic Monthly,* May 1981. His stricture is applicable to Calcutta, New York, and Mexico City alike. To permanently benefit needy people, a gift must stimulate hope, promote self-reliance, and provide a bridge to a better life. This kind of input will make better neighbors, and perhaps trading partners.

In feeding our nation, agriculture employs a significant proportion of the labor and industrial force in supply, distribution, and processing of food. The agricultural sector thereby provides a tax base to support the several levels of government. Our perception of priorities has not yet recognized society's obligation to protect the soil base with a just proportion of the taxes thus generated. Generous Federal funding for soil conservation is a modest insurance premium on the goose that lays the golden-egg.

In terms of technology, soil conservation readily serves the ends of financial prudence and energy conservation. Except for original equipment cost, conservation tillage can be done economically, in many cases at a saving over conventional tillage. But it is a new art. Our experience and our research are limited. If the farmer, gambling his future, must choose between untried conservation tillage and the conventional tillage which he understands, both he and his banker or landlord may opt for the known system, even though aware of the soil loss risk. Many farmers are at a point where a failure in 1983 means no more chance at all.

Conventional tillage optimizes the soil environment by increased aeration, reduced stratification of fertilizer, more rapid drying of soil and warming of the seed bed. These traditional advantages entail high soil erosion and costly fuel consumption. In order to justify advocacy of conservation tillage, it will be necessary to identify the minimum amount of soil disturbance which will result in optimum soil environment for each soil type. Growing popularity of minimum tillage is evidenced in Iowa: with some 26-million crop acres in Iowa, in 1982 all but 9.6-million of those employed some degree of minimum tillage or no-till. Conservation Commission biologists and the Soil Conservation Service are now studying the manifold effects of no-till on wildlife. The advantages are reflex. In our area, row crops on 3 percent or greater slope require some conservation practice to hold the soil loss to a tolerable level. Contouring will cut the soil loss about 50 percent. Conservation tillage, which leaves 50 percent or more of the ground covered, will cut the soil loss about 50 percent; no-till will reduce it by 75 percent. On slopes over 8 percent and over 300 feet long, there is no substitute for terraces and water control structures, expensive and inconvenient though they may be.

Symbiosis is a good word among us. Co-habitation is a useful word which has acquired risque connotations. But for a wildlife-oriented conference, we must convey the fact that we humans do not live alone on this planet, but that its resources are a joint habitat for diverse species. Our co-habitants provide us with food, fertilizer and energy, while their aesthetic value is immeasurable. All of you are familiar with Stephen Jay Gould's thesis that no species on this planet is immune from extinction *unless* by luck, self-discipline, and rational planning the human species may be able to prove itself the exception. I cannot recommend reliance on luck, so let us examine an instance in which self-discipline and firm action by society through government benefited symbiotic species, one of them the human.

Volume 11, No. 6 of *Ambio,* a journal of the Royal Swedish Academy of Sciences, tells in an article by H.S. Panwar how India secured a 62 percent increase in population of endangered tigers through a 10-year program. During the colonial era, tigers were hunted for sport by the affluent, but large wilderness forest tracts maintained sufficient protected habitat to insure a balance of wildlife species. Within this ecosystem, the tiger was an essential factor, controlling population of deer and other ungulates. With Indian independence, "development" projects to reclaim forest land, irrigate marginal land, and both cultivate and graze those lands (sound familiar?) exposed tigers to ominously rapid human predation. By 1972, the country's tiger census had dropped from 40,000 to only 1,827 animals. These few specimens were endangered by poachers who slaughtered for the valuable, faddish skins, and by farmers whose livestock the tigers took as substitute for the deer and other natural prey vanishing along with them from the areas annexed for agriculture. Control of hunting and restoration of habitat was urgent if the elegant animals were to be saved as a part of the cultural heritage. To control hunting, the Indian Board for Wildlife secured a national ban on tiger hunting. The poachers themselves became the hunted.

The Wildlife Protection Act was passed in 1972. Advocating this long-range conservation program, Prime Minister Indira Gandhi said, "It (the tiger) is at the apex of a large and complex biotape." To restore habitat, human competitors for space had to be resettled. To create "core" areas of undisturbed forest reserve, 27 entire villages, not without initial protest, were removed to better agricultural land, supplied with fertilizer and improved seed, and offered low-cost financing . So greatly improved was life for the villagers relocated in the first wave, that by their own request 17 additional villages were similarly transplanted. Buffer areas, in which agriculture was strictly regulated and supervised, surrounded the "core" wilderness reserves from which all human presence was removed. The illustration here is that there are circumstances under which society, through government, must say to squatters on misused or abused land, "you are in the wrong place, doing the wrong thing; financial incentive and technical assistance will be given, but desist you must."

It is said that man is the only species to live upon the face of the earth who can change and modify that face at will. I believe that he can perpetuate that species if he will respect that habitat which he shares with other species. A balance of pressures upon the ration of land available to each benefits all.

To cope with the constraints we face in the management of land and water resources, we must promulgate and adhere to a conservation ethic which stipulates conservation-with-change.

During 1982, radar on the space shuttle, scanning the surface of the Sahara, detected mysterious, unidentified traces on the sands of time. Analysis proved these to be the dried beds of a vast system of ancient rivers, some as wide as the Nile. These mighty rivers vanished eons ago, and were buried by the migrating sands. George Will, conservative economist, describing this discovery in January 3, 1983 column in *Newsweek,* reflects that "even mighty rivers . . . are mortal."

Man and planets are mortal, too.

The inexorable flow of the Mississippi, bisecting providentially fertile farm land, may in some distant century be marked only by a vague line on a radar scan, unless that land is accorded respect and even reverence by its stewards.

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Aldo Leopold's Challenge to Educators

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Fifty years ago, the nation inaugurated a president who promised a New Deal to a people prostrate in the most severe depression in its history. Five thousand banks had failed, 1,000 farm mortgages a day were being foreclosed, and 25 percent of the national workforce was unemployed.

Among the unemployed was Aldo Leopold, age 45, father of five, who had already achieved national prominence in two professions—forestry and game management. After an exemplary career in the Forest Service in Arizona and New Mexico, Leopold had risen to associate director of the U.S. Forest Products Laboratory in Madison, Wisconsin, then the principal research arm of the Forest Service. In 1928, a year before the great crash, he left the security of government service to begin laying the groundwork for a new field of endeavor, a new profession—game management—modelled on the profession of forestry.

It was a classic mid-life transition, accomplished with little outward evidence of personal crisis yet at a time of profound dislocation for the nation as a whole. Under funding from the Sporting Arms and Ammunition Manufacturers' Institute, Leopold conducted game surveys in eight midwestern states and set up a series of game research fellowships at five universities. He also chaired a committee of the American Game Conference (forerunner of the North American Wildlife and Natural Resources Conference) that formulated an American Game Policy emphasizing habitat management and professional training. And he picked up several months' work as a consultant conducting additional game surveys in Iowa and Wisconsin. But during the darkest years of the depression, 1931 and 1932, the Leopold family subsisted in part on grubstakes from Aldo's devoted mother in Burlington, Iowa, while he doggedly persisted in writing the book that would serve for generations as the standard text of the new field, *Game Management*.

As Franklin Roosevelt was inaugurated in March 1933, Leopold was reading final proofs of *Game Management* and sending circumspect notice to professional colleagues that he was "available for any sort of work, permanent or temporary, regardless of location, which will advance wildlife conservation." Within the month, Congress established the Civilian Conservation Corps (CCC) and by summer 300,000 young men aged 18–25 were on the federal payroll assigned to 1,300 work camps in national forests and parks around the nation. Aldo Leopold hired on as a consultant to the Forest Service to supervise erosion control work by CCC boys in dozens of camps in the mountains of the Southwest.

It was while he was in the Southwest on the erosion project that he presented what was undoubtedly to be the most important address of his career, "The Conservation Ethic." It opened with the literary allusion familiar to readers of his later "Land Ethic"—"When god-like Odysseus returned from the wars in Troy"—and went on to trace the extension of ethical criteria over the centuries from relationships between individuals to relationships among individuals in society and eventually, he hoped, with the land community. It was also while he was in the Southwest that a faculty position was created for him at the University of Wisconsin, a chair of game management supported by an unprecedented grant from the Wisconsin Alumni Research Foundation. (He had offered himself as the focal point for a new graduate program of conservation research at the university as early as 1928 and on several subsequent occasions, but it required the fresh air of the New Deal, with its receptivity to new social and economic ideas, finally to spring the position.) Leopold's chair was lodged in the Department of Agricultural Economics in anticipation of its contributions in the realm of land utilization—development of a productive game crop for hard-pressed Wisconsin farmers.

Thus within a few months in the spring of 1933, Leopold completed the transition from unemployment and uncertainty to the career pattern that would distinguish his remaining years. In April he published the pre-eminent text in the new field of game management, in May he presented his first clearly articulated statement of his environmental philosophy, and in June the regents of the university accepted the grant for the new academic chair that he occupied until his death in 1948. The three events were clearly interrelated. Each in its own way signalled Aldo Leopold's commitment to the educational process that he had decided was the only answer to the problem of conservation.

The new text was an educational tool designed for practitioners and students of game management, professionals in related fields, and what Leopold termed "the thinking sportsman or nature-lover." It was written to encourage curiosity and "the scientific point of view" and succeeded so well that it remained in use long after much of the specific research on which it was based had been superseded.

Leopold's address on "The Conservation Ethic" elaborated what the text merely asserted—that the purpose of endeavor in the new field and of ecological education in general was to bring about a new attitude toward the land. "Civilization is not . . . the enslavement of a stable and constant earth," Leopold wrote. "It is a state of *mutual and interdependent cooperation* between human animals, other animals, plants, and soils, which may be interrupted at any moment by the failure of any of them." The ultimate issue, as he viewed it, was whether people had the desire and the ability to comprehend the world in which they lived. The challenge of education was fundamental and formidable: it had to stimulate the *desire* for comprehension and extend the *capacity* for informed, independent judgment.

"Economic laws may be permanent," Leopold granted, "but their impact reflects what people want, which in turn reflects what they know and what they are." Such factors could change through the process of education.

It is conceivable that Leopold himself might not fully have appreciated the gauntlet he was throwing down to educators. Or taking up for himself. Certainly, in his first few years as a professor at Wisconsin, he seems to have underestimated the magnitude and complexity of the task. He began by establishing demonstration areas and working with graduate students and local farmers to plant cover crops and food patches for various game species. The idea was to apply what was already known and gain quick dividends that would cause the techniques to be more widely adopted. But the plants and animals refused to cooperate. Plantings failed and populations rose, then plummetted, not always in sequence or in response to discernible causes.

Within about four years, as the initial five-year grant for his chair was drawing to a close, Leopold began to reassess the situation, and a spate of reports and publications dealing pointedly with education began to flow from his pencil. In his own operations at Wisconsin he determined to cut back on the demonstration areas, take fewer graduate students, and work with them more intensely on what he called "deep-digging" research into basic population mechanisms and ecological relationships. At the same time, he cooperated with professors in other fields in a series of interdisciplinary surveys, known collectively as the "Science Inquiry," to assess ways in which the university might more effectively marshal its resources to address problems of vital concern to the state and nation. The committee he chaired on "The University and Conservation of Wisconsin Wildlife" recommended not only a more comprehensive program of ecological teaching and research but also a shift of emphasis to what he termed "cultural" teaching (as opposed to professional training), in order to raise the level of citizen understanding of ecological processes. For himself that meant converting his survey of game management (a technical skills course) into a broader course on wildlife ecology for general undergraduates, aimed to create the capacity for critical judgment on conservation problems.

With professional audiences at wildlife conferences and in various journals, Leopold (1937b) minced no words. He was especially disillusioned with the alphabetical agencies of the New Deal, each in its own single track, one program often functioning at cross purposes to another to the ultimate detriment of wildlife and the land. Partly it was a consequence of too much money too fast, but partly also of inadequate science, an emphasis on application in advance of research. Research manpower and dollars, such as they were, had gravitated to the "easiest, quickest, cheapest, most popular" field—farm game—leaving out waterfowl, rare species, fish, songbirds, and wildflowers. "No advance ever attains an even front," he granted, "but good generals remove kinks when they can. Our front is full of kinks, especially in the non-gunpowder sectors." To be sure, it was a barrage intended to encourage the strategic movement of troops. But when he leveled his guns on professional training, many in his audience must have felt his direct aim. For he was charging that in response to open federal money-bags, universities had rushed to turn out quantities of mediocre, half-trained managers instead of highly trained ecologists or discriminating citizens. In 1933 there had been perhaps 10 trained game managers; by 1937 the Wildlife Society, a fledgling professional organization, had 450 members. That was overstocking the market, in Leopold's judgment.

In his presidential address to the Wildlife Society in 1940, he took a more positive approach, pointing to an "almost romantic expansion" in professional responsibilities for wildlife managers. They had begun with the job of producing something to shoot, but they might end by contributing a new definition of the purpose of science. Most definitions dealt with the creation and exercise of power, he said. "But what about the creation and exercise of wonder, of respect for workmanship in nature?" Such a query took him into the realm of education for laymen and teachers. "Why do so many universities spend most of their wildlife funds and use their ablest men in training professional managers when the greater need is for wildlife courses for the general student body and for prospective teachers?" he asked. Two years later he addressed the North American Wildlife Conference on the same theme, this time under the title "The Role of Wildlife in a Liberal Education." Again he looked toward the removal of the senseless barrier between the sciences and the arts, and called on his colleagues in the wildlife profession to lead the way. Wildlife was inherently interesting; it was the perfect entree to stimulate the desire for comprehension of larger issues.

Before looking more closely at the purposes and content of education as Leopold envisioned it, it may be appropriate at this point to go back to review briefly his own educational experience. Although he earned a masters degree in forestry at Yale and thereby became one of the elite in the new profession, it was his early fascination with wildlife and his broad-based liberal education that gave him his sense of values and his capacity for growth. Moreover, it has seemed to me, from a close reading of his letters and such school papers as survive, that the basic pattern of his life was set before he ever left Burlington, Iowa, at age 16 to attend the Lawrenceville Preparatory School in New Jersey and the Sheffield Scientific School at Yale. The major influences on him seem to have been his mother and father, his grandfather, and a few teachers in the Burlington public schools, who encouraged both his love for the out-of-doors and his respect for the written word. His writing skill was well developed before he left Burlington, and he honed it thereafter in literally thousands of letters home. Likewise, his curiosity about the world of nature and his penchant for long, solitary "tramps" became habitual in Burlington, later to be nourished in the woods and fields around Princeton and New Haven. The eastern schools clearly deepened his understanding and appreciation of the sciences, history, and literature, though even here it is clear he was often leading from strengths developed initially at home or in the Burlington schools. Aldo Leopold in his school days can best be described as a naturalist, in the mode of widely published naturalists of the day like John Burroughs, John Muir, or the young Theodore Roosevelt.

When he suddenly entered the world of professional forestry his senior year at Yale, he became thoroughly captivated by surveying, mapping, planning, planting, tabulating, and all the other technicalities of the craft. His enthusiasm for the new profession, at Yale and in his early years in the Forest Service, seemed to overwhelm his naturalist bent, though from time to time the earlier proclivities surfaced. The breadth of learning, extraordinary perceptiveness, and strength of values he had developed early in life gave him a firm base from which to challenge his colleagues in forestry during the 1920s for too-rigid adherence to certain scientific "dogmas" and too narrow a conception of professional responsibility. He pushed repeatedly against the limits of the profession, especially with respect to development of new lines of work in wildlife management, erosion control, and preservation of wilderness. Similarly, in the 1930s, despite his own enormous influence in shaping the profession of wildlife management—no one saw more clearly than he the need for firm institutional foundations for technical training, research, publication, and standards or worked more effectively to create them—Leopold retained his critical faculty. And his sense of humor. He concluded a 1938 address to the North American Wildlife Conference with a note on the wildlife profession's contributions to the human comedy:

> The privilege of pulling the curtain strings on The Unknown always engenders priestcraft. We who divine the future for snipe and woodchuck mystify our congregations by the same devices as those who propound the law for sect and synagogue. It is an amusing coincidence that both enhance the stage effects by generous use of Latin.
>
> Is there danger in these scientific struttings and boomings? I think not, so long as we have the grace to laugh when some wag sticks a cockleburr in our professional robes and vestments.

Thus Leopold was never a prisoner of narrow professionalism. In his critique of forestry, his mid-life transition to wildlife, and his frequent challenges to the wildlife profession, as well as on numerous specific issues over the years, he revealed his own remarkable capacity for intellectual growth and independent judgment. His commitment to these qualities, in professionals and in laymen, is nowhere more evident than in his views on the education process—especially his dedication in the last decade of his life to education for citizenship.

Leopold began thinking in terms of educating the general public to take a more responsible role in conservation when the shortcomings of the New Deal brought home to him the limits of reliance on government agencies and resource management professionals. His thinking on education for citizenship was also in part a response to a law passed by the Wisconsin legislature in 1935 mandating the teaching of conservation in public schools. It was a law sponsored by the Federation of Women's Clubs and other laymen's groups, and Leopold regarded it as well-meaning but perhaps wishful thinking. He was asked for advice on subject matter and teaching materials and responded with an article on "Teaching Wildlife Conservation in Public Schools." Much of the scientific basis for conservation courses did not yet exist, in his view, much less materials in a form usable by teachers. Materials on identification and habits of species—taxonomy and natural history—were relatively abundant, but teaching based solely on such materials would hardly address the needs of conservation. To understand conservation issues and policies, the citizen-conservationist required also an understanding of ecological and management questions, and these would ultimately require special materials prepared on the basis of particular regions or states. The examples he gave of books that might be adapted for such use, Paul Sears's *Deserts on the March* and *Little Waters* by Person, Coil, and Beall, leave little doubt that he included human history, institutions, and values in his definition of ecology. Nor was he willing to shield students from confrontation with conservation controversies. He suggested using materials produced by various conservation organizations that would show how different conclusions could be drawn from identical facts.

Such dissonance would force the student to confront the question of his own personal philosophy of land use, the ultimate objective of ecological education.

A word is in order here on the changing uses and meanings of the word *ecology*. As originally coined to describe Darwin's concept of the economy of nature, ecology was defined as the study of the relationships of organisms and environment, including all the conditions of existence, which could, of course, include the human and institutional as well as the biological and physical. As a scientific discipline in the United States in the early twentieth century, however, ecology was dominated by botanists interested in describing stages of vegetational succession in a pristine environment wholly independent of human activities or, for that matter, of other disturbing influences such as wildfire or disease—all of which were regarded as "unnatural" forces acting from outside the system to upset an otherwise stable equilibrium. This was the conceptual approach that dominated the forestry profession at the time Leopold was a student and practitioner; it dominated early animal ecology, too, and remained imbedded in the teaching of both plant and animal ecology in colleges and schools until well into the post World War II period (Egler 1951). Its tenets, I suspect, are still imbedded in some of what passes for environmental education today.

Aldo Leopold from the start developed a much more dynamic, holistic understanding of ecological relationships—one that viewed human activities, institutions, and values, as well as wildfire and other disturbances, as functioning parts of an integrated system—probably because of his broad educational background, his early interest in Darwin, and his penchant for relying on his own independent observation. On many of the points on which he challenged traditional Forest Service doctrine in the 1920s, such as the causes of erosion, the perils of overgrazing, and the role of fire (Leopold 1924), he was in effect challenging the dominant ecological conception of the day, even without realizing it and even though elements of that conception penetrated and to an extent distorted his own thinking, especially about wildlife populations. Elsewhere (Flader 1974) I have described in some detail the fusion of ecological and evolutionary theory in the 1930s in the biological sciences in general (and in Leopold's own thought) that issued in what has been termed by some the "ecosystem concept," described by Leopold (1939) as "the biotic idea," and by many, including Leopold, still termed simply "ecology."

For our purposes here, it is important to note that virtually whenever Leopold used the term ecology—occasionally before the mid-1930s and frequently thereafter—he used it in a dynamic, holistic sense, and he included in the concept human activities, institutions, attitudes and values as well as so-called "natural" processes. "Land Ecology discards at the outset the fallacious notion that the wild community is one thing, the human community another," he once asserted (1942b). One of my favorite passages in which Leopold describes his ecological approach does not even use the word ecology, perhaps because it comes from a relatively early source, his book *Game Management:*

> It is astonishing how few of those who have learned by rote rule or "nature study" the *statics* of the land's present inhabitants or condition, ever learn to read the *dynamics* of its past history and probable future. To see merely what a range is or has is to see nothing. To see *why* it is, how it *became,* and the direction and velocity of its changes—this is the great drama of the land, to which "educated"

> people too often turn an unseeing eye and a deaf ear. The stumps in a woodlot, the species age and form of fencerow trees, the plow-furrows in a reverted field, the location and age of an old orchard, the height of the bank of an irrigation ditch, the age of the trees or bushes in a gully, the fire-scars on a sawlog—these and a thousand other roadside objects spell out words of history, and of destiny, of game and of people [pp. 387–88].

As an historian, I have long been impressed by Leopold's profound consciousness of history. Reflect for a moment, if you are familiar with *Sand County Almanac,* on the workings of history in some of his greatest essays: Marshland Elegy . . . Odyssey . . . On a Monument to the Pigeon . . . Good Oak . . . Thinking Like a Mountain . . . Song of the Gavilan . . . and, of course, The Land Ethic. This historical consciousness is not mere predilection; it is integral to an ecological comprehension of land. History is the dynamic of human culture and environmental change. Leopold was interested in the dynamic—in history—because he was concerned about destiny. In his teaching, as well as his writing, he turned increasingly in the 1940s to the use of case histories, preparing cases on subjects as diverse as a prairie coulee, northern Wisconsin, a horned-owl territory, a fencerow, central Wisconsin marshlands, and an Ozark farm. In fact, his untimely death cut short a plan to write a new textbook for a more general, cultural course, such as his course in wildlife ecology, using the case history approach.

The case history that drove the problem of education home to him most pointedly in the last decade of his life was the problem of deer and forests in northern Wisconsin (Flader 1974). It was a problem that could not be understood apart from the dynamics of the situation: Deer populations had increased exponentially during the 1930s in response to widespread forest reproduction resulting from newly effective fire control in the old cutovers. The burgeoning herds were overbrowsing vegetation and, in Leopold's judgment, had to be reduced drastically for the long-range health of both forest and wildlife. But the public, relying on attitudes and policies developed a decade or two earlier, still regarded deer as a scarce commodity that should be protected and increased. The situation was far more complicated than this brief summary can suggest, and Leopold was relentlessly embroiled in it until his death. It was this case that inspired one of his most poignant statements about education, in his 1947 address to the Garden Club of America on "The Ecological Conscience":

> We speak glibly of conservation education, but what do we mean by it? If we mean indoctrination, then let us be reminded that it is just as easy to indoctrinate with fallacies as with facts. If we mean to teach the capacity for independent judgment, then I am appalled by the magnitude of the task.

But that is precisely what he did mean—to teach the capacity for independent judgment. And that implied a capacity to remain mentally alert and receptive to new ideas and new conditions throughout life, to be able to deal with dynamic situations. A person "educated" as to "correct" policies for conserving deer in the 1920s could not apply that knowledge to the problems of the 1940s without understanding what had transpired in the meantime—not only in the northwoods but in the minds of people. Even with the best available information, he might not be certain exactly what had happened and, even if he did know, the situation would still be in process of change, so that he would have to be able to deal with flux and unpredictability. Uncertainty, after all, is part of the ecological scheme of things. As Leopold once told an extension class on the subject of teaching conservation (1937), "Sound management does *not* give protection from all the slings and arrows of misfortune; it does give an environment fit to fight in." The challenge is not only to learn *about* the ecosystem, but to develop an ecosystem perspective—to develop one's intellect, or thought process, in congruity with one's understanding of the way the system functions.

And there is yet another challenge—the imperative of action. It was in an article in *Audubon Magazine* during World War II, titled "Land Use and Democracy," that Leopold addressed most pointedly the problem of the need for action, even in the face of incomplete knowledge. "Conservation education appeared, before December 7, to be making considerable headway," he began. "Now, against a background of war, it looks like a milk-and-water affair. War has defined the issue: we must prove that democracy can use its land decently." Instead of relegating the burden of conservation to government, in the manner of the New Deal, Leopold called for the ordinary citizen to learn how to tell good land-use from bad, to use his own land accordingly, and to "refuse aid and comfort" to those who did not. This was the democratic approach, "conservation from the bottom up, instead of from the top down." It required "hitching conservation directly to the producer-consumer relation," instead of to government, with government now assigned the role of "tester of fact vs. fiction" (truth in advertising) and "guardian of technical standards." From an educational perspective this approach was ideal, because it could be implemented with cases that presented an "intellectual gradient" suitable for all ages and degrees of land-use education. "No one person, young or old, need feel any obligation to act beyond his own personal range of vision," Leopold observed. But one did need to feel an obligation to act.

"Land Use and Democracy" is one of the least known of Leopold's essays today, forgotten because it seemed so visionary at the time. For that very reason it might bear closer scrutiny now, after the revolution in consumer and environmental values in post World War II America.

Most of what Aldo Leopold wrote during the last decade of his life—including the essays in *Sand County Almanac*—was intended as a contribution to the education of a general rather than a professional audience. Not a majority, for he did not believe there was a majority out there who would *care,* but a small group of like-minded people that he hoped would grow. "For us of the minority," he wrote, "the opportunity to see geese is more important than television, and the chance to find a pasque-flower is a right as inalienable as free speech." And again, "The case for a land ethic would appear hopeless but for the minority which is in obvious revolt against these 'modern' trends." This citizen minority was the group he wished to bring by stages along the path of perception to a capacity for independent judgment and ethical action.

Today that minority who care bids fair to become a majority, and the challenge for educators is thereby immeasurably increased.

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Obtaining Constituent Feedback: Implications for Conservation Programs

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Introduction

The two basic communication tasks facing wildlife management organizations are (1) disseminating conservation information and (2) obtaining constituent feedback. Most wildlife agencies have long traditions of presenting the conservation message to their constituencies using a variety of informational and educational approaches. Wildlife code books, magazines, news releases, movies, slide shows, and educational publications have proven effective over the years in explaining management programs and fostering the public's conservation consciousness.

Not so prevalent, however, are mechanisms for obtaining feedback representative of a constituency's view on an agency program or wildlife issue. Feedback usually consists of letters to the agency, phone calls and personal contacts. These methods meet the important need of allowing individuals to express their opinions, but may not give the wildlife professional a valid impression of the sentiment of the constituency at large. Moreover, resource professionals face the challenge of monitoring wildlife-related interests of not one constituency, but many. The expectations and behavior of the traditional harvest-oriented clienteles figure in program decisions, as well as the desires of aesthetic-oriented watchers, photographers, and natural history enthusiasts. Agencies are having to acknowledge the demands of preservationists and protectionists. Private landowners are seen by many wildlife professionals as the group most in need of being heard if habitat conservation is to progress in coming years. Finally, and perhaps most difficult to respond to, are calls to determine the "needs of the general public," and incorporate these into management decisions.

One approach to sorting and understanding this confusing array of constitutent interests is survey research. Since 1976, when the Missouri citizenry approved a constitutional amendment initiating a one-eighth percent sales tax to help finance conservation of the state's fish, wildlife, and forests, the Missouri Department of Conservation has completed nearly 40 social surveys to assist resource managers in understanding what people know about conservation and what they expect of Missouri's conservation programs. This constituent feedback has helped agency staff evaluate and manage ongoing programs, new programs, and "crises."

Following are descriptions of the use of survey research to obtain constituent feedback for (1) evaluating an ongoing agency program, (2) guiding development of a new program, and (3) managing a "crisis." Each description provides general applications and a case study of the management situation.

Program Evaluation

General Applications

A wide variety of organizational efforts can be evaluated using survey research. Questions common in program evaluations are, "How effective is our service?" and "In what ways could we improve?" Information about respondents' interests and personal characteristics is useful in understanding their answers to these questions.

Program evaluations rarely yield empirical oddities, or results unexpected by agency staff. Agency personnel often have sufficient familiarity with the program and enough public contact to have an intuitive grasp of its overall effectiveness. Though no areas requiring major changes are likely to emerge, the program evaluation is particularly useful in identifying elements of a program in need of minor adjustments.

Case Study: Missouri Conservationist Magazine

Background. One way a conservation agency can maintain contact with its clientele is to publish a periodical. The *Missouri Conservationist* is a monthly magazine produced by the Department of Conservation and distributed at no cost to Missourians who request it. First published in 1938, the *Conservationist* currently is sent to over 300,000 addressees, making this group one of the largest and most identifiable constituencies of the Department.

Associated with increasing size of the mailing list was growing curiosity among the magazine's staff as to the readership's background characteristics, outdoor interests, and opinions of the magazine. Was the magazine satisfactorily serving those receiving it? If so, why? And if not, how could it be improved?

This desire for constituent feedback resulted in a readership survey during the fall of 1982. A questionnaire was sent to each of 1,000 randomly selected readers to collect information for a reader profile. After two follow-up mailings, 841 questionnaires were returned (84 percent response).

Selected Results. Respondents received the *Conservationist* for an average of nine years. The youngest reader in the survey was a six-year old, and the oldest, 99 years. Readers averaged 49 years in age. Average size of respondent household was three members. Nearly all adults and school-aged children in homes receiving the magazine looked at the publication. Twenty-one percent of magazine recipients passed their copies on to friends and relatives, so survey results suggested that the *Conservationist* audience is on the order of one-million Missourians, about 20 percent of the state's population.

Readers were offered a list of 34 different topics that the magazine covered in recent years and asked to rank the items as to interest. On the average, streams, fishing, and rivers were the top three, with "how-to" articles, endangered species, and natural areas the next three. Wildlife management, humor, public recreation areas, and hunting were the remaining topics in the top ten.

Reading interests varied somewhat by selected characteristics. Women, for example, rated wildflowers, natural areas, endangered species, streams, and wildlife art as their five most preferred topics, while men most preferred fishing, streams, rivers, "how-to" articles, and hunting. Differences in topic preferences also existed on the basis of reader age, education, and urban versus rural residence. However, the survey revealed that every magazine topic held at least some interest for readers regardless of selected background characteristics. One area for improvement readers identified was inclusion of a letter-to-the-editor column, which has not been a feature of the magazine in the past.

Management Implications. As anticipated, the survey did not identify any elements of the magazine requiring major changes. However, the findings confirmed two general perceptions held by the magazine's staff. First, the *Conservationist* readership represents a highly satisfied, long-time customer of the Department of Conservation. In light of the group's size, it is an ally of formidable political and financial clout. Second, the readers are not homogeneous in their reading preferences, desiring a wide variety of harvest-oriented and aesthetic-oriented topics. The magazine apparently satisfies the majority of readers by offering a selection of articles nearly as diverse as reader preference. In fact, the magazine provides a common ground where individuals with varying wildlife backgrounds are exposed to both familiar and unfamiliar conservation topics.

The survey results indicated that at least two minor adjustments in the magazine warranted consideration. First, in light of the fact that practically all children in households receiving the magazine look at it, a special feature for youngsters might be effective. Second, a letters-to-the-editor column apparently is needed to satisfy the majority of readers who feel that constituent feedback should be a regular part of the magazine.

Program Development

General Applications

Development of natural resource programs based on constituent input may strike some wildlife professionals as opening the door to resource mismanagement. However, in some contemporary issues and topics requiring action from the wildlife management profession—particularly those of a "people" orientation—managers may find that (1) their training, experience, or knowledge is insufficient or (2) their opinions on the questions at hand are no more valid than other citizens who have interests and experiences in common with wildlife managers. If the wildlife administrator imposes a decision on opinionated citizens who feel their views were not solicited, the administrator might encounter resistance to the decision, or worse, precipitate an undesirable political crisis.

An exploratory theme underlies questions useful in program development: "What would you prefer;" or "What has been your experience?" Collection of background information such as age, sex and outdoor interests will provide clues to why respondents feel as they do. Agency personnel developing the survey must have enough of a grasp of the topic to formulate questions. Lacking this intuition, help should be sought outside the agency to develop questions which will yield meaningful answers.

Surveys used to help develop programs often produce surprising answers. Constituent responses may go against conventional wisdom or "common knowledge." On occasion, rather than being decisive, the answers to this type of survey stimulate so many new questions as to require further study.

Case Study: Expansion of Private Lands Program

Background. The farmer is one of the most important characters in the story of wildlife conservation in the United States. The amount of land managed by the agricultural community exceeds that in public ownership, so private land managers may well determine the degree of future successes in wildlife management.

In Missouri, the Department of Conservation has developed a field service program around farmers seeking wildlife-related assistance from the agency. Established in 1938, the Wildlife Division's Field Service Branch is currently composed of 12 agents and one coordinator. Also assisting landowners are the Conservation Agents of the Protection Division, who number about 150 and are located over the state's 114 counties. The most common types of help provided at no charge to landowners are development of wildlife management plans for individual farms, provision of food and cover planting materials, and advice concerning site selection and management of small water impoundments.

With passage of Missouri's Conservation Sales Tax came the opportunity to expand the field service program. But what types of services would farmers prefer in the expanded program? Advice? Planting materials? Possibly, but these have been criticized by some wildlife professionals as being simplistic and of limited scope. Instead, some professionals suggested that paying cash to farmers would be the most effective and far-reaching method to encourage wildlife management practices on private lands. Revenues from the Conservation Sales Tax allowed the Department of Conservation to at least consider implementing a cash payments program. But would farm operators welcome cash payments? If not, what other types of assistance would be welcomed?

A study of Missouri farm operators was completed during the spring of 1980 to answer the foregoing questions, and gain clues useful in expanding the field service program (Kirby et al. 1981, Sheriff et al. 1981). A sample of 9,367 farmers was selected from a statewide list of 123,996 farm operators. Of 8,993 questionnaires delivered, and after two follow-up mailings, the final number of usable forms returned was 5,264 (59 percent response).

Selected Results. When asked if they would welcome assistance for improving their land for wildlife, 41 percent of all respondents said "yes." An additional 6 percent indicated "possibly," but the remaining 53 percent answered "no." Farmers who indicated they would not welcome help were asked to explain why. The answer given most frequently was "don't want to attract hunters" (30 percent), followed closely by "don't have enough land" (29 percent). Some felt they "already do enough for wildlife" (18 percent). Three answers given infrequently were "can't afford it" (8 percent), "too much time involved" (6 percent), and "don't want wildlife on the farm" (2 percent).

Farmers who said they would welcome assistance were asked to indicate what types they desired most, second-most, and third-most. Most favored by a plurality of respondents was "seed for food plots" (27 percent), though technical advice ranked a close second (25 percent). Of the 5,355 answers for types of assistance desired most, second-most, and third-most, "seeds" accounted for 19 percent of the total, "advice" for 19 percent, and "plants" for 15 percent. "Tax considerations" was the most cited form of monetary assistance (13 percent), with "cash payments" ranking fifth (12 percent) in types preferred. Mentioned infrequently were "fencing" (9 percent), "equipment" (4 percent), "other types" (1 percent), and "no preference" (8 percent).

Management Implications. Conventional wisdom has long held that wildlife management on private lands would be most effective if wildlife could become a staple product of agriculture rather than a by-product. Moreover, it has been suggested that, if only given the opportunity, farmers would capitalize on the prospect of making wildlife marketable—say, by accepting cash payments in return for implementing wildlife conservation practices (e.g., Harmon 1981). The results of this survey did not support conventional thinking. Strong evidence was provided that cash payments rank behind food plot seeds, advice, plants, and tax considerations in types of assistance desired by Missouri farmers for wildlife conservation practices on their lands. The expanded field service program, which was implemented following the survey, was one emphasizing demonstration of wildlife conservation practices to farmers and provision of planting materials, rather than one based on direct cash payments.

The expanded private lands program began on July 1, 1981 and will continue as a pilot project for five years, throughout which the effects of the program will be evaluated. The program consists of five major elements: (1) develop and manage two Department-owned farms to show economically sound farming operations that ensure soil and water conservation and produce wildlife as a by-product; (2) place a new field service agent in each of three counties to intensively "market" planting materials and advice to landowners; (3) establish a new position of "agricultural liaison" responsible for encouraging communication and cooperation between agricultural agencies and the Department of Conservation; (4) supply technical advice and assist landowners in establishing native warm season grasses; and (5) participate with the Soil Conservation Service in two federally funded soil erosion control projects, each of which includes a private lands wildlife specialist to develop farm plans that benefit both erosion control and wildlife.

Crisis Management

General Applications

Rare are the wildlife administrators who enjoy formulating decisions and establishing policy in an emotion-charged, crisis atmosphere. Far too frequently, however, administrators or commissioners are forced to consider action while they are opposing persons who take exception to a proposed or existent wildlife policy. These individuals may give strength to their position by claiming to represent the views of a sizeable portion of a particular constituency. In the absence of data reflecting the constituency's view, such a claim can assume unwarranted credence. Wildlife conservation agencies must beware of the ". . . danger of inferring that the media-attracting hyperbole of extremist spokesmen accurately reflects the rank and file . . ." of the constituency; rather, ". . . an agency's response to any interest group should be based on some understanding of its members and their beliefs, not simply what is portrayed by the popular media" (Shaw 1980:39).

Resolution or management of crises can be greatly enhanced by soliciting the opinions of the particular constituency "burdened" by a policy. The nature of questioning is, "Do you favor/disfavor? Approve/disapprove? Support/do not support? Or have no opinion?'' Inclusion of the ''no opinion'' response category is particularly important in surveys on crisis matters, especially if members of the ''general public'' are to be sampled on the issue, many of whom may not have formulated an opinion on the topic. Background information on respondents should also be collected to help understand their opinions on the issue.

Results from a survey of this nature will help administrators manage the situation by showing whether the opposition view is the minority or majority opinion. If the former is the case, crises on wildlife-related matters often dissolve. If the opposition view is indeed the majority opinion of the constituency affected, the wildlife administrator need not reverse the policy, but certainly should be prepared to justify its continuation on the basis of sound biological or fiscal considerations.

Case Study: Missouri Waterfowl Stamp

Background. In February, 1979, the Missouri Conservation Commission unanimously approved a state waterfowl stamp costing $3.40 to be required of all waterfowl hunters 16 years of age and older beginning with the 1979 waterfowl season. This fee was in addition to the federal waterfowl stamp and state hunting permit requirements. The decision was, in part, based on a 1978 survey (Humburg and Sheriff 1978) of waterfowl hunters indicating that 74 percent of those responding favored the state stamp. In November, 1979, in response to opposition to the stamp by some waterfowl hunters who claimed to represent the public, the Commission requested two studies to thoroughly assess sentiment toward the stamp. The first was a mail survey of 11,232 of 56,749 individuals who purchased state waterfowl stamps in 1979. After one follow-up mailing, 7,054 usable questionnaires were returned (63 percent response). The second study was a telephone survey of the general public completed for the Department of Conservation by Fleishman-Hillard, Inc., a St. Louis-based polling firm. Telephone interviews with Missourians aged 18 and over totaled 497.

Selected Results. Sixty-eight percent of the stamp purchasers ''favored'' the program; 29 percent indicated, ''disfavor''; and 3 percent had ''no opinion.'' Sixty-three percent of the sample from the general public had not even heard of the state waterfowl stamp before being contacted for the survey. After hearing the program explained, 59 percent ''favored'' the stamp; 7 percent indicated, ''disfavor''; and 34 percent had ''no opinion'' on the issue.

Management Implications. The high level of support shown by stamp buyers for the program was especially meaningful in that they were program participants. The group upon which financial responsibility for the program falls had roundly supported continuation of the stamp. Additionally, the timely and thorough manner in which the staff had been able to deal with waterfowl hunters highlighted the value of the state waterfowl stamp in providing a sampling frame from which a comprehensive program of waterfowl research has since proceeded.

The waterfowl stamp requirement appeared to be a ''non-issue'' to the general public, despite the public support claimed by those opposed to the stamp. The fact that a majority of Missouri adults had not even heard of the stamp, yet favored the idea of requiring it, supported the notion that the general public trusted the judgment of the Commission in matters of conservation. The controversy over the state waterfowl stamp subsided almost immediately following the release of survey results.

Discussion

Just as wildlife agencies must be able to monitor the status of wildlife populations to do an effective job, so too should agencies remain aware of their human constituencies' interests and concerns. Survey research is a method of obtaining feedback representative of a constituency's sentiment on a wildlife issue or agency program.

We wish to emphasize that being responsive to the public does not imply that opinion information should dictate wildlife management policy. Professionals trained in biology and wildlife management techniques are best able to determine strategies for accomplishing the specific goals of wildlife conservation. But wildlife policy involves more than biology and management techniques. The essence of policy formation is the assignment of priorities, which sometimes entails weighing biological management alternatives in view of management philosophy of the department's commission, fiscal constraints, prevailing legislative climate, and constituent feedback.

Data concerning constituents are not only useful for answering immediate questions on program effectiveness and direction, but also provide a source of information for future reference. Unlike political polls and surveys on social issues, results of which can be highly changeable over a short time, constituent feedback on wildlife-related topics, in our experience, generally is useful for years following data collection.

Wildlife professionals might be uneasy about the process of completing a survey because of unfamiliarity with certain technical aspects of the task. Assistance in such matters can be gained from university or private consultants. If agencies lack the finances for outside consultation, then agency staff can undertake the project by first consulting "How-to" manuals on survey research (e.g., Weiss and Hatry 1971, Dillman 1978), and then proceeding by following a tenet of survey work—*keep it simple, manageable and understandable.* Wildlife biologists should be able to formulate questions that provide answers to the problem or issue at hand. Other agency staff, such as data managers, biometricians, and fellow biologists, can provide technical assistance in analyzing the data.

It has been suggested that one of the greatest compliments which can be paid someone is to ask, "What is your opinion?" Obtaining constituent feedback not only provides agencies useful information for decisionmaking, but also renders a compliment to the special insights which only the governed can provide the government.

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Using National News Media in Wildlife Conservation Information

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The wildlife management profession today has the greatest opportunity in its history to increase public understanding and support of its discipline. Public interest in wildlife has grown steadily over the past two decades as additional constituencies have become aware that they have some stake in the outcome of wildlife resource issues.

According to a 1980 survey by the U.S. Fish and Wildlife Service, more than half of all Americans participate in some form of wildlife related outdoor recreation. And millions more are directly affected by the outcome of wildlife related issues involving energy and housing development, road construction, land clearing and other issues that have enormous public policy implications. Even the most seemingly innocuous regulation or policy proposed on a State or Federal level is closely monitored by a host of interest groups, lobbyists, and organizations ready to litigate, wage massive write-in campaigns, and otherwise battle to win opinion.

The public's perception of the Watt Administration's personalities and policies toward wildlife resources has further thrust discussion of wildlife issues into the news media like never before. And as the real and perceived issues involving wildlife are reported and debated on the front pages of the nation's newspapers and on the evening news, public interest in wildlife has never been greater.

This news coverage has certainly benefited wildlife conservation in some ways, such as by making the public more aware of the problems of endangered species or the dangers of environmental degradation. But as Fish and Wildlife Service public affairs officer George Sura notes, "front page coverage is a bittersweet blessing." It gives wildlife managers a chance to publicize wildlife problems, but also, for reasons that will be discussed later, it can result in oversimplification or distortion of complex issues and lead to polarization of public opinion.

While wildlife now receives more attention from the news media, social, political, and economic considerations make it unlikely that news stories will contain adequate information about wildlife management issues.

First, the audience for wildlife news has changed. More people live in large urban areas today than in the past. This affects wildlife management because, as Dr. Stephen Kellert found when he surveyed public attitudes, the majority of people living in large cities know much less about wildlife and their habitats than do people who live in rural areas. With much of the audience for wildlife news lacking a personal knowledge of wild animals, it is easy for misconceptions to spread.

Second, organizations with an interest in the outcome of wildlife resource issues are making greater efforts to plead their causes in the national news media. Some of the organizations employ people who are highly skilled at dealing with the news media, and they generate legitimate, worthwhile news coverage. Others, however, use these skills to exploit successfully the media's tendency to report controversy.

Some of the more extreme groups have been quite adept at getting headlines by making emotional charges against Federal and State government policies or practices. This has not always been good for public understanding of the wildlife management profession.

At the same time, however, most Federal and State agencies are generally less able to communicate effectively with the news media now than in the past. Most agencies are cutting back on information programs because of dwindling budgets or because of conscious policies to reduce contacts with the news media. In many agencies, contacts with the media are primarily reactive—that is, in response to information the media have already obtained from another source. There is not enough effort by government and private professional wildlife management organizations to initiate news coverage.

Indeed, wildlife resource managers have not done an adequate job of improving the news media's and the public's understanding of wildlife management. They have basically stood still while the public's attitudes changed and the anti-management groups and other special interest groups have very effectively gotten their points of view before the public.

The results of this situation could be seen from Maine to Florida during 1982 as the news media gave intense coverage to efforts by various groups to halt public hunts proposed by professional wildlife managers. In perhaps the most extreme example, the Smithsonian Institution was prevented from holding a deer hunt in an endangered species breeding compound where there was a severe overpopulation of white-tailed deer. The public outcry about the planned hunt was so great that a special Congressional hearing was called and the chairman of one Congressional committee proposed that the Smithsonian spend hundreds of thousands of dollars to translocate the deer and build a deerproof fence around the compound. This figure is more than many States spend on their entire environmental education and public information efforts.

What does all of this mean to the wildlife management profession? First, there is no reason to believe that news media or public interest in wildlife is going to decrease. News contacts with reporters at the U.S. Fish and Wildlife Service have doubled over the level of a few years ago, and most of the contacts are initiated by the reporters themselves. We must expect that we will have to work more frequently with the news media as a regular part of our jobs.

Second, if we're going to have our side of the story told accurately, we're going to have to develop more sophisticated techniques, attitudes, and better working relations with the news media. In many respects, wildlife managers have been their own worst enemy. While special interest and anti-management groups have increased their dealings with the news media, some of the most respected and influential wildlife organizations have not opted to emphasize media interaction in their day-to-day operation. Wildlife resource professionals have tended to cling to one of two philosophies—either they try to avoid the media, or they place too much reliance on them as a "tool" that can be used to educate the public. In the following discussion we will review some of the characteristics of the news media and suggest some ways we can work with them more effectively.

Characteristics of the News Media

For a number of years, the information office of the U.S. Fish and Wildlife Service has received many more calls from general news media than from the outdoor writers who traditionally have been the major target of information efforts by wildlife managers. As a result, we now find it necessary to direct most of our public information efforts not toward the outdoor press, but toward the general, national news media.

Before we can improve the accuracy of news coverage on wildlife management, we must first know who the news media are and how they operate.

Who are the national news media? Loosely defined, they are the wire services—Associated Press, United Press International, Gannett, Scripps Howard, and others. They are the television networks and the national news magazines—*Time, Newsweek,* and *U.S. News and World Report.* And they are the major daily newspapers, some of which have national audiences, such as the *Los Angeles Times, New York Times, Washington Post,* and the *Wall Street Journal.* Of course, outdoor writers, the sporting and conservation magazines, and local and regional news media are very important in providing information about wildlife, and many people's opinions are influenced by their coverage.

Generally speaking, however, the major national media are more influential because of their enormous audiences and their ability to cover breaking news very quickly. They have the power to create or change public opinion literally overnight. A recent example of this was the network coverage of an attempt by an oil company to drill a well on a wilderness area in New Mexico. After seeing the film of oil company employees pushing environmental protesters out of the way of a bulldozer, how many people could resist the notion that this was a black and white issue, evil developer versus Mother Nature? And yet we know the real issue was far more complex than that.

The news media are particularly effective in covering certain types of stories. We at the Fish and Wildlife Service have had considerable success working with them on law enforcement cases and recovery efforts for endangered species, for example. But our experience, which is based on a large number of contacts with a broad range of reporters, indicates that there are limits to the media's ability to "educate" the public about wildlife management. These limits—which also apply to coverage of many issues besides wildlife—are due largely to the nature of the media and the constraints under which they work. Let's take a quick look at some of these.

Most national news reporters are generalists who have little background in wildlife management and only a vague notion of what we do or how the laws we operate under work. Most reporters are typically bright and intelligent, and are trained to be highly skeptical. While there are some excellent environmental reporters and some journalism schools now offer degrees in environmental journalism, there is normally a rapid turnover in personnel assigned to the environmental beat. In fact, many news organizations do not even have distinct environmental beats—they combine it with another subject area, such as science or labor. Reporters do not have time to learn the field, as they may be assigned to cover wildlife one day and a transportation strike or political event the next. Their lack of background knowledge sometimes makes them more vulnerable to manipulation by the more extreme organizations that have their own axes to grind. It can also create difficulties when they are writing about a complicated issue and sometimes results in unintentional distortions.

Reporters usually don't have much time to spend on a story. If you don't get a reporter the information he or she needs in time to meet the deadline, the reporter will use information obtained from someone else. Animal rights and protectionist groups are very quick to offer up an emotionally charged quote that is good for instant controversy and a flashy headline. The story is often already written by the time a response to the reporter's inquiry to a government agency finally grinds its way through the bureaucracy. Usually reporters, pressured by deadlines, are simply unable to spend the time needed to fully comprehend the complexities of an issue, but sometimes they are just plain unwilling.

Competition is fierce for air time and column inches. Take, for example, Marty Crutsinger, the environmental beat reporter for the Associated Press. He covers not only the Fish and Wildlife Service but the activities of the other bureaus in the Interior Department, such as the Bureau of Indian Affairs, Bureau of Reclamation, Minerals Management Service, National Park Service, U.S. Geological Survey, to name a few, plus the activities of the Secretary and the Assistant Secretaries. He also covers the Council on Environmental Quality, Environmental Protection Agency, the entire Department of Energy, and dozens of special interest groups. He receives about 200 news releases a week and more than 100 phone calls and visits from people suggesting stories. He also gets assignments from his editors. Out of all this he will write 15 to 20 news stories. Newspapers with 87 percent of the nation's total daily circulation subscribe to A.P.

Television networks are even more reluctant to go to the expense of committing a camera crew and reporter to a story. Television news must boil down each story into no more than a minute or two of air time, and it is very difficult to communicate the complexities of any issue in this kind of format. Our experience at the Fish and Wildlife Service indicates that when the networks want to cover a wildlife story, they prefer to avoid complex resource issues in favor of more cut-and-dried stories and, of course, if no dramatic footage can be obtained, the chances of a story are diminished.

Reporters and their editors look for conflict. With many newspapers competing for readers and advertising at $106,000 a minute on CBS Evening News, a comprehensive informative story (all else being equal) almost always loses to one that is controversial or entertaining.

In the last two years at the Fish and Wildlife Service, we have seen a much greater number of stories that emphasize personalities or politics rather than issues, as well as more stories that are inaccurate, misleading, irresponsible, or carelessly written. In no way do we mean that this characterizes all news reporters, nor do we want to attribute causes for these problems, but some of the reporting has been quite poor.

For example, the *Wall Street Journal* reported on its front page that Matagorda Island, Texas, was the only nesting area of the whooping crane. Of course, Matagorda is a wintering area for the birds and is not even used by most of the whooping crane flock. But this error may have had a significant effect on public perception of the controversy over disposal of Federal lands on Matagorda.

A similar careless error was made by a major Florida paper that lambasted the Fish and Wildlife Service for its policies that would turn national wildlife refuges into Coney Islands. It cited as an example an area called Corkscrew Swamp. Not only were there no such policies, but the area was not even a Federal refuge. It belongs to the National Audubon Society. The editors had not checked this fact even though the swamp was just a few miles away.

Not long ago we received a call after business hours on the day before a holiday from a reporter for a well-known national newspaper. She was writing about controversies involving half a dozen national wildlife refuges and had already spent considerable time talking with a protectionist group that had made inaccurate charges and assumptions regarding Fish and Wildlife Service policy. Although we needed some time to gather facts to respond to some of the charges, she said she could not wait to file her story.

The *Washington Post* recently ran a story about the fact that Assistant Secretary Ray Arnett exhibits photos of hunting scenes near his office in the Interior Building, with the implication that this offends some people. This hardly seems like a significant issue warranting coverage by a major national newspaper.

Some reporters will go to any lengths for an "entertaining" story. Once I got a call from a reporter for a major paper who wanted to write a story about any endangered species with a funny name that was blocking a development project.

While some of this type of reporting is no doubt due to the bandwagon of reporters trying to capitalize on the controversial nature of the current Secretary of the Interior, not all of it is. Regardless of who is Secretary, over the years there has been an increase in "formula news reporting." The formula is this: a government agency takes an action, a non-governmental group (or sometimes, an industry) criticizes this action, and presto: instant controversy. There is little coverage of the actual issue. If the news article can make references about the political motivations or personality of an official involved, so much the better.

These kinds of situations occur just as frequently in other areas where there are highly visible, controversial issues and personalities as they do in the wildlife field. Whenever there is a high-profile individual or a controversial subject matter of national prominence, news coverage will be mixed. Some stories will be tagged on the personality, others on the conflict or the politics.

Some reporters are satisfied to call a person they can count on to give them a colorful quote rather than seek the most knowledgeable or appropriate spokesman. Lately, however, some reporters who regularly cover environmental topics have told us they feel that spokesmen for some private groups have lost credibility by continually making exaggerated or inaccurate charges. But generally, the atmosphere makes it easier for the media to be influenced by emotional statements or inferences made by private groups.

Once an inaccurate article is written, it can quickly become the basis of further news stories and editorials. Recently, a major newspaper ran an editorial criticizing a Service official for statements that appeared in a story in another paper—yet the official never made these statements. No one from the editorial department called to check the accuracy of the original story or verify the quotes before the editorial was written. We have also seen instances in which letters to the editor, sent to correct inaccurate stories or editorials, were themselves edited or reworded in such a way as to soften the criticism or make the letter misleading.

How Can We Use the Media More Effectively?

There are actions that wildlife managers can take to overcome some of these problems and capitalize on the heightened public interest to improve news coverage of wildlife resource issues.

Most important, government wildlife agencies and professional management organizations must be adequately budgeted and staffed with people who are effective communicators and who are experienced in working with the media. Their job is to help the press separate discussion of legitimate issues and differences of opinion from emotional rhetoric and misinformation. This must be a continuous and coordinated information program—it cannot be a one-shot effort. Wildlife administrators must rely more on the expertise of their communications staff, seek their advice earlier, and be guided by their counsel as seriously as they are by their scientific or legal advisors. The wildlife management community is the first to resent non-professional advice on how to manage an elk herd or promulgate hunting regulations, yet some managers do not hesitate in deciding when or whether, or how or how often, to communicate with the public. Their personal opinion or perspective of the public and/or the media all too often supercedes or overrules the experience and training of their communications staff.

An information program is more than just issuing a news release or putting out a brochure. It is also timing, strategy, anticipation, perception, communication skills, feedback, and credibility. To do an effective job, however, the information staff must have direct access to top management and must be included in major decisions so that they are aware of actions that may become newsworthy. They must be well informed so that they can respond to news inquiries and correct inaccurate stories quickly, and they must have the latitude to initiate news coverage of issues, problems, and successes.

Second, wildlife management groups must pay more attention to social science research on the attitudes and characteristics of different publics. We cannot afford to be complacent about the biological merits of wildlife management activities and ignore the social or political consequences. Wildlife managers generally have placed little emphasis on research designed to understand their various user publics.

Professional wildlife management must develop a more enlightened attitude toward the news media and communicating with the varied publics. Often wildlife managers are reluctant to deal with the media for fear of adverse coverage or lawsuits. Sometimes there is even disdain for the media's function and a disregard of the public's right to know.

We must make efforts to overcome the media's skepticism toward the credibility of government officials. This skepticism is sometimes fueled by the media's suspicion, frustration, or inability to gain access to top officials. One way to overcome this is to encourage face to face interviews between reporters and wildlife biologists. Some agencies also hold seminars for reporters on specific subjects by their experts. The U.S. Geological Survey, for instance, held one on volcanoes. The Bureau of Reclamation held one on water management. While these seminars are excellent for improving accuracy and building rapport between officials and the media, in and of themselves they cannot overcome reporters' skepticism of government or government spokespersons. On a long term basis, experienced professional communicators can help build credibility for an agency by being responsive and forthright.

Beyond this, Federal and State agencies and professional organizations should seek opportunities to work with the private sector. Many corporations now actively support wildlife conservation activities and can be of great assistance in disseminating accurate information about wildlife in their public relations and advertising efforts.

But more important, we must do much more to pool our communication resources and work together on regional and national public information efforts. In these times of reduced budgets, we should expand our cooperation in the production and distribution of public service announcements, films, slide-tape programs, literature, and "media events," and better coordinate communication efforts to the news media and to the various publics they serve. A good start in this area has been the activities of the Southeastern Association of Fish and Wildlife Agencies, which has coordinated production and distribution of information materials on several issues that are common to its member States. The Fish and Wildlife Service and Atlantic and Mississippi Flyway States are now undertaking a joint public information program on the black duck—the first time such a coordinated effort has been tried at the national and State level.

A great deal more can be done in this area. The Fish and Wildlife Service recently made an informal survey of State information offices and asked for prepared materials on five specific topics. From the responses we received, it is apparent that there is still much duplication of effort in the preparation and distribution of basic information for public distribution. At the same time, there is little or no information on subjects that are very important yet misunderstood, such as predator control. No wonder three-fourths of the American public does not know coyotes are not an endangered species.

One step toward correcting such situations might be the formation of a top level task force of representatives from State and Federal agencies and professional wildlife groups. Such a task force could develop plans for short and long term public information activities aimed at correcting widespread misconceptions and generally building understanding and support for wildlife management activities. For example, agencies could agree to themes or goals for parts of their information programs. The cost of preparing any materials needed to support the concerted effort would be shared among the participants. Since the media would be covering the "theme" for an entire year, the public would be exposed to the kind of continuous information that is necessary to reinforce its knowledge and memory of the issue or idea. A modest amount spent on such coordinated information activities could be very cost effective in preventing frivolous court challenges to the biological soundness of decisions.

Of course, education projects in the schools are a vital part of any information effort. In the long run, these formal educational projects are the cheapest, most effective way to create public understanding, and you will shortly hear about some of the best education programs in the nation. But we must remember the power of the national news media to form public opinion overnight. In a marketplace where we must compete with many others for attention and space, much more effective communication measures are essential to creating publics that are more knowledgeable and less easily manipulated by emotional or inaccurate charges. There has never been a greater need or potential for change than now. And how we seize this opportunity over the next several years may ultimately be as great a factor in protecting wildlife resources as any wildlife management policy or initiative.

We must ask ourselves, if people in the East think coyotes are endangered, who is communicating the information needed to correct this notion? Whose responsibility is it to attempt to point out the facts? Is it the Federal Government's? The States'? Wildlife professionals'? The answer is, of course, it's all of our responsibility.

Publicizing Conservation Needs

Ron Way
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In their book, *Public Relations and Communications for Natural Resource Managers,* Fazio and Gilbert stated the obvious: ". . . good public relations is not missed until needed. Sooner or later it is realized that good public relations could have prevented most of the catastrophies which have resulted from poor public relations."

The meaning of good public relations is broad and its application covers activities from a cheery telephone voice to well-planned, targeted mail campaigns using computer-sorted lists. But it all comes down to effective, positive communications so that people understand and appreciate what you—and your organizations—are doing. The objective in good public relations is to win public confidence in and support for your cause.

We in the conservation community appreciate the value of good public relations. Too often, however, full appreciation of the value comes too late.

Writing in the December, 1982, issue of *Wyoming Wildlife,* Harold J. Harju of the Wyoming Game and Fish Commission told of the need for the legislature in his state to support the Wildlife Trust Fund to protect wildlife habitat under stress from energy-related development. In his article he summarized a problem confronting wildlife managers in Wyoming, but the problem is shared elsewhere:

> . . . Development has reduced the amount of available wildlife habitat and we have not been able to keep up with the activities of other agencies as well as we would have liked. As the state's population has increased, hunter access has declined, and in response to the increase in resident hunters we have reduced nonresident license sales to preserve quality hunting. This has also decreased our revenue. Landowners have lost some of their patience as the number of hunters has increased. . . . We are now faced with declining support for game management as the percentage of the public that hunts declines. . . .

Development . . . reduced habitat . . . population up . . . hunting success down . . . declining support for game management. . . . The refrain is familiar.

At Front Royal, Virginia, the Smithsonian Institution, faced with a growing problem of increasing deer populations inside its large corral for exotic zoo animals, planned a hunt to reduce the deer herd. Opposition to the hunt was immediate and it was strong, and in the emotion of the moment reasonable and sound proposals for wildlife management were lost. The issue was not proper resource management.

The most famous wildlife management controversy of 1982 was, of course, the emergency hunt ordered by the Florida Game and Fresh Water Fish Commission in an attempt to stem the starvation of deer in the Everglades. National attention was focused on South Florida last summer, but for the most part the attention was not on water mismanagement, which is a major cause of the serious wildlife-management problems in that state. The attention was not even on the unbelievable starvation that was occuring and would continue to occur without a culling of the herd. The issue, again, was the hunt itself. The press told the nation a story about hunters and anti-hunters in South Florida last summer—but the press (with some notable exceptions) did not tell the story of a fragile ecosystem in disarray.

As the episode simmered and the national press corps left, Bob Brantley reflected on "the Hot Summer of '82" in his column in the November-December issue of *Florida Wildlife:*

> . . . We in the Commission have learned that wildlife management practices, no matter how well founded on biology and management principles, can become highly controversial if it is not understood and accepted by the general public, particularly if there is opposition providing misinformation and distorting the facts. More information and education about wildlife management and the role of hunting are obviously needed. Such an information and education process is difficult to achieve once a controversy has begun. . . . The majority of the news reporters knew little of the Everglades, deer or wildlife in general and therefore centered on what impressed them or seemed most newsworthy. . . .
>
> It is evident that people are concerned about wild animals, but that concern should be broadened to extend not only to an individual animal but to entire populations and what is best for the majority.
>
> . . . What an asset it would be if those people who were so concerned about the Everglades deer became actively involved in opposing the real threats to our wildlife—uncontrolled development, pollution and other forms of habitat destruction.

Those responsible for wildlife management in this country should memorize the last part of Bob Brantley's column; they should do a lot of thinking about what he says in the first part. The Everglades hunt should serve as a warning of what is wrong about the "reactive" approach to educating the public on the principles of wildlife management and conservation. Because everyone who has been in Bob Brantley's situation will tell you that the opportunity to educate often ends when a controversy begins.

So, where do we start with the business of helping the public understand the business of wildlife management?

First, we must ask if people care. In this case, do they care about environmental protection and conservation of natural resources?

From every measure they do. Polls conducted by a variety of reputable organizations over the past 24 months have come to the same conclusion: the American public wants clean air, clean water, healthy living conditions and space for recreation and wildlife. The feeling is strong in every region of the country, and the extent of the support for conservation was dramatically evident in the special Lou Harris poll conducted for the Natural Resources Council of America and released in December, 1982. The poll found that, when given a choice between strict clean-water standards and jobs, 65 percent of the people say they would endure plant shut-downs and people thrown out of work rather than repeal the requirement that companies install the best pollution-control systems available.

Clearly, the issue of environmental protection and conservation enjoys the highest degree of public support in the history of the movement. Leaders of both political parties now agree that environmental protection is a major political issue in the country.

Second, do people care about wildlife?

Bob Brantley says they do. Many others agree. Charles Greene, a producer of the new television syndication, "Lorne Greene's New Wilderness," attributes the early success of the show to the strong public appeal of wild animals.

Third, do people understand wildlife management?

There is little evidence that the public has translated their concern about the condition of the environment into an understanding of the principles that guide the work of natural resource managers. Dirty air and water evokes a response; protecting upland habitat to promote a diversity of wildlife escapes attention, just as the wildlife effects of water mismanagement in South Florida have escaped attention for years.

The problem seems clear enough. And ironic: at a time when environmental protection and conservation enjoy such a high level of support, the same people who support them either are not getting or not understanding the message of wildlife management. I would argue it is both. We in the conservation community surely cannot expect that the public will understand a message—the critical need for wildlife management—that they are not getting.

The U.S. Fish and Wildlife Service is the world's greatest assemblage of wildlife managers. They are directly responsible for millions of acres of wildlife refuges and special management areas. They are indirectly responsible for helping ensure that wildlife habitat is not needlessly destroyed by federally-supported development. And they are responsible for administering programs that provide state wildlife agencies throughout the nation with many of the funds the states need to look after the condition of wildlife habitat in their areas.

The U.S. Fish and Wildlife Service is perhaps the best-suited agency of government to meet the public's demand for more information on conservation and resource protection. Yet the public affairs budget of the Service has been reduced sharply, resulting in a substantial decrease in the ability of wildlife managers to spread the conservation message through the commercial media.

The preparation of this report included a survey of 13 conservation or environmental organizations to determine the extent of their public relations efforts with the media. With cutbacks in PR activities by the federal resource agencies and state game and fish agencies, the survey was conducted as an attempt to determine whether private organizations have stepped in to fill the public-education void. The surveyed groups included (in alphabetical order): Clean Air Coalition, Ducks Unlimited, International Association of Fish and Wildlife Agencies, Izaak Walton League of America, National Audubon Society, National Parks and Recreation Association, National Wildlife Federation, Safari Club International, Sierra Club, Sport Fishing Institute, Wilderness Society, Wildlife Management Institute, and The Wildlife Society.

The groups were selected because of their common interest in conservation and environmental affairs. It is recognized that the resource-management objectives of the organizations vary considerably. Some are professional organizations that develop small memberships of certified resource experts; some are organizations that exist to serve a membership of other organizations; some are organized for the specific purpose of promoting their cause through developing public and legislative support. It follows that the media-relations objectives will vary along with each organization's reason for existence. Survey results for each of the organizations will not be reviewed—only general observations will be made.

Of these groups, Sierra Club and its cause is perhaps the best known. Its PR efforts are closely linked to its aggressive lobbying activities, and the media attention it gets is considerable. The National Audubon Society and the Wilderness Society also capture considerable media attention, as does the Clean Air Coalition when news of the Clean Air Act is reported. Over the past two years, the National Wildlife Federation (NWF) has become more "proactive" in its media affairs efforts, particularly in resource-related news reports.

With the exception of the NWF, the organizations that are best known in the national media are groups that generally promote issues other than professional wildlife management. The survey also found that, with exception of NWF and the Izaak Walton League, the wildlife or conservation management organizations assumed a "reactive" approach to media relations. In other words, they promote their organization's cause in response to calls from the press; they generally do not seek publicity.

Broad categorizations are difficult because there always are exceptions. However, some general statements about the PR activities of wildlife organizations can be made.

1. In addition to generally being "reactive" rather than "proactive" in their media relations, the wildlife management proponents generally focus their PR activities on educating their own members. The public education objectives that these organizations profess seldom are pursued.
2. Where there are some attempts to promote wildlife management principles through the media, the strategy of the wildlife groups is based almost solely on the issuance of news releases. At NWF, we have found that the news release has only limited value in an effective PR program. Complementary efforts are necessary.
3. The Sierra Club, National Audubon Society, Wilderness Society and Clean Air Coalition list PR functions as major organizational objectives. Of the wildlife-management organizations, only NWF and the Izaak Walton League consider PR activities as major organizational objectives.

Since he took office as the National Wildlife Federation's Executive Vice-President two years ago, Jay D. Hair has determined to assign a major priority to develping an effective public affairs program. The NWF is a conservation education organization that promotes wildlife-habitat management principles. The NWF is continuing its highly effective conservation education program through curriculum development in the schools and through the sponsorship of wildlife research. At the same time, Jay Hair has determined that effective conservation education embraces a number of activities, including: participating in professional wildlife organizations, reviewing our conservation interests with members of the Congress and officials in regulatory agencies, and developing an effective media relations program to foster support for the NWF's conservation cause. At NWF, my responsibility is to manage the public affairs department. I am assisted by an administrative aide and four professionals.

Like most public affairs offices, we rely on news releases to promote our cause. Over the past 12 months we have issued more than 140 press releases that, depending on content, are sent to more than 12,000 media outlets on our mailing list. Included in our releases are full-length features on stories that appear in *Ranger Rick* or our wildlife magazines *(National Wildlife and International Wildlife)*. The features are sent by third class mail to weekly and small daily newspapers (about

8,000 in total number). Releases that contain information of a more timely nature are sent by first class mail to the largest media outlets in Washington or to media in selected regions of the country. For fast-breaking situations (such as a reaction to a major decision by the government) our releases may consist of a short statement that is messengered or telephoned to the major news outlets.

There are a number of other public affairs activities undertaken at NWF:

1. Each year we produce a broadcast public service announcement for distribution to 650 television and more than 1,000 radio stations. The PSAs support NWF's annual National Wildlife Week theme. Last year's PSA on eagles was narrated by Robert Redford, and the 1983 PSA promoting public lands is narrated by Loretta Lynn.
2. A new feature begun only recently consists of three separate "Conservation Tipsheets" that provide summaries of story and feature ideas for reporters. NWF resource experts are listed as contacts for follow-up on each of the tipsheets, which are mailed monthly to (1) large metropolitan daily newspapers, (2) small daily newspapers and the broadcast media, and (3) outdoor writers.
3. Speeches are prepared for delivery by the Executive Vice-President. Op-ed articles are developed from the speeches and distributed to editorial page editors throughout the country.
4. A "Media Contacts Guide" for the press was published in December and will be updated every six months. The guide lists resource subjects in alphabetical order. For each subject, there is listed at least one NWF resource expert, along with the office and home phones for that person.
5. Considerable time is spent in informal sessions with reporters. Luncheon sessions involving the Federation's executive staff and reporters are arranged to help reporters understand some of the complexities of resource issues and to develop or maintain good working relationships. Reporters tend to write (or at least call) news sources whom they know and trust. Personal contact with reporters is important in developing trust.

For the immediate future, the NWF is planning to embark on two ventures that hold high promise for further promoting our conservation cause. One is to develop training workshops in media relations for our field staff and for leaders in our affiliate organizations. The other is development of a commercial television series on wildlife featuring a star personality and an exciting story line that will attract a large number of viewers.

With the on-going and planned activities, the National Wildlife Federation intends to promote its image and the conservation cause through the news media. For wildlife management principles to be understood and accepted by the public, wildlife management proponents must adopt a "proactive" public relations posture.

Role of Federal Wildlife Information Offices

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The role of Federal wildlife public affairs offices is, in part, self-explanatory: to make information about Federal wildlife conservation efforts available to the public. But within this straightforward mandate, there exist many subtleties and complexities that must be recognized and respected if the goal of communication is ever to be achieved.

Over the past 10 to 15 years, public affairs offices in Federal wildlife agencies have experienced a marked change in function and duties. The general trend could be characterized as an increase in responsibility, with a decrease in elective capability to initiate conservation awareness efforts. Both situations arise from greatly enhanced public interest in wildlife and resource topics, and from the growing intensity of media coverage and scrutiny from "watchdog" organizations. Thus, much wildlife public affairs effort is now reactive at the Federal level, responding to public/media inquiry, criticism, or support to increasingly visible issues. Further defining the current situation for fish and wildlife public affairs offices are the budget concerns now widespread throughout the Federal and public sectors. The net effects of these circumstances are that Federal public affairs offices are likely to be far more sophisticated than in the past. They have to be more skillful, discerning, and selective regarding effective use of money and staff resources in their treatment of resource topics than in times past—but at the same time they are operating under more limitations than previously.

With this background in mind, we can proceed to look at both the changed role and the continuing goal of fish and wildlife public affairs efforts.

The most significant change—one not yet widely recognized even in the resource community—is the sharing in policy-making responsibilities. This new development was born of necessity: resource managers have become more and more aware that their resource decisions cannot be made in a vacuum. They must represent at very least some acknowledgement of public attitudes and outlooks. Pure biology, pure economics, pure administrative efficiency do not and cannot exist in the public resource arena. There are always qualifiers and contingencies that interact to produce real-world resource decisions and resource policies. Prudent resource managers have always acknowledged this and have worked this principle to great public advantage—they have created public policy that served both the public and the resources to the greatest extent possible. With the dramatic rise in special interest resource groups since the 1960s, however, the decision-making equations have become far more complex. And the services of trained and experienced public affairs specialists, to both evaluate public perception and to help strategize and articulate agency policy goals, have become essential to modern resource management.

The Fish and Wildlife Service was one of the first Federal resource agencies to establish a communications/public affairs office with a policy function as part of its position; the first to confer Service directorate level ranking and participation. When this was done, nearly 10 years ago, it was with the full recognition that public wildlife policy could not issue and be effected without public input, support, and understanding. Too often, decisions are made by administrators and their immediate staff without the public affairs input at the policy, program development, and execution levels. When this happens, the public affairs program is only a disseminator of information. I want to make clear that the Fish and Wildlife Service wasn't establishing an in-house PR firm; it was not setting up a mere information service geared solely to the needs of one or two constituencies. It was establishing a public affairs office whose overall goal was to participate in the management of the agency and provide the public with timely and accurate information regarding wildlife resources, especially those for which the Fish and Wildlife Service has significant responsibilities under law.

Among the early operating premises in 1973 (and one that carries forth to this day) was that wildlife resource issues were indeed newsworthy and important aspects of the public trust that all citizens should at least be aware of. Thus, we made direct efforts to work with national news media—in part because we perceived the media was slow to realize the importance of these stories, and slower still to assess public interest in wildlife and related natural resources. In the past 10 years, there have been some dramatic changes. The major news organizations now regard resource issues, particularly wildlife, as major news. This has brought about the need for increased specialization among our information staffs. It is now necessary for us to have content specialists who can devote significant time and energies to being our interim "experts" on the breaking stories and most visible (and controversial) resource topics of the day. Similarly, we have staff specialists whose expertise lies in various communication functions, such as audio-visual, media liaison and motion picture production.

The advent of specialized staff has helped us serve a greater variety and larger volume of information/media inquiries than in times past. Not surprisingly this has created a lot of new "spin-off" interest—references and topics passed on to other writers, reporters, producers, etc., who may have never heard of the Fish and Wildlife Service before. Thus, the results for some of our initial outreach efforts have been a seemingly unending supply of new and repeat media contacts. A good circumstance, by and large, but at times a mixed blessing.

With a marked increase both in volume of work and the visibility or sensitivity of the topics we deal in, it has become essential to pay special attention to the sensitivities involved in resource issues. We have encouraged our staffs to be particularly attuned to serving public and press needs, while recognizing the legitimate managerial prerogatives and initiatives of the leadership in the Executive Branch. That may sound to some like a balancing act, or a tightrope; in fact, it is not and need never be if sensible and forthright limits are established up front, in a professional manner, with media *and* with management. Public information in any endeavor is built on trust. So too with wildlife information. It is our task to see that the agency speaks clearly and effectively to its concerned publics, that information is conveyed that accurately reflects biological realities, and that top management's goals and policies have been articulated fully and faithfully.

That, basically, is our job: we work for the Department of the Interior, on behalf of this country's resources and its people. We are responsive to the wishes of the offices of the Secretary and the Assistant Secretary for Fish and Wildlife and Parks in their goals to articulate their valid points of view to the Fish and Wildlife Service resource constituencies. Conversely, we are responsive to the resource community and relay their special concerns back through our information system.

In our daily workings with the media both in the Washington office and the field, we try to achieve a balanced perspective and mode of operation with all inquirers—whether it is a major television network or a small daily serving just a few thousand subscribers. We spell out what's available, and where and how we can help; and we try to offer additional supportive information or necessary background on the biology or natural history of many of the siutations we deal in.

It is the policy of the Service to have all media inquiries referred to public affairs for response. This has two purposes. It relieves the amount of time required that non-public-affairs managers have to spend with the media, and it assures, to the degree possible, that responses accurately reflect current Service and Departmental policies. We don't "give away the store." Nor do we play cat-and-mouse. Our time is too valuable and we assume that the reporter's is as well. We have found this direct, helpful approach the most effective in relaying our important information and in saving everyone's time.

There's an old saying that before you can know the tricks of the trade, you have to know the trade. This is especially true in wildlife information. You don't have to be a biologist or resource specialist, but you do have to have both a knowledge of and an interest in wildlife resources—and a willingness to learn more each day.

In the Fish and Wildlife Service's public affairs effort, we are very concerned about the quality of our communications—not simply the professionalism of our style, but the accuracy and integrity of the content of our messages. This combined approach of solid information delivered in a professional manner has proven its value to top resource managers, to the media, and to the public.

In summary, there have been many changes in wildlife information efforts at the Federal level during the past 10 years. These changes reflect increased press and public interest in resource issues, and the growing realization on the part of resource agency administrators that the public affairs effort is now an integral part of any sound management equation. The managerial and policy roles of public affairs reflect an overall maturing of the resource management process in this country. These changes reflect the reality that has long been present, but seldom publicly acknowledged in wildlife circles: "pure" wildlife biology, just like "pure" communication theory, cannot effectively function in the real-world environment of a modern resource agency. A team approach—calling upon the skills and backgrounds of many diverse specialists—can best integrate valid public concerns with legitimate management prerogatives and biological priorities. This approach will likely remain the most effective one for resource management in this country.

A Practical and Professional Approach to Conservation Reporting

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There is no excuse for poor news reporting in our business—conservation and natural resource management. Resource management has a built-in reservoir of good will. It is a popular cause; it is on the side of the angels.

Most problems that arise are of our own making and are agreeable to internal solution. We can be our own best friend . . . or worst enemy.

I've spent more than 25 years as a professional communicator—13 years on daily newspapers, and 14 years in conservation and outdoor writing. In that time I've learned that one of the most underappreciated persons in an organization is the one who maintains the image of that organization—the newsman.

People buy newspapers and magazines to read what writers have to say. They rarely if ever buy them for the advertising, yet that is where the money lies. In the same sense, public perception of a conservation agency is shaped by what the public reads and hears of it.

It stands to reason, then, that a good newswriting organization can greatly enhance the image of any conservation or resource agency. Not entirely, of course. No information section, not matter how talented, can gloss coat an administrative clown who makes news by being a fool. On the other hand, a smoothly professional agency can remain largely unknown and unappreciated without good reporting.

The one thing we in conservation have to face is that perhaps two-thirds of all the people in North America don't care a thing about what we do. They aren't necessarily opposed to us—they just don't care. In fact, I suspect those who are enemies of what we stand for know as much if not more about us than some of us do. They must in order to be effective enemies.

We recently commissioned a study of the Missouri Department's information program. One major conclusion was that there is a wide pool of people uninformed about us. How do we reach them? We're still trying.

Who are they? Well, they range from the abjectly poor to the very rich. Ghetto residents have little contact with the outdoors and probably little chance ever of becoming our constituents. On the other end, our consultant polled members of his exclusive men's club and found they didn't know anything about the Missouri Department either.

In between are other groups ignorant of us—little old ladies who don't birdwatch, many city kids, perhaps struggling young breadwinners with their noses to the grindstone and no time for the outdoors.

Is it worthwhile to reach and possibly sway this group? Perhaps. I give a qualified answer because I'm not convinced it's worth exceptional effort. What we can do, I think, is try to expose them to our messages and hope that some of it soaks through the torrent of NFL football, "One Day At A Time," golf, bowling, whatever. It's naive of us to expect the indifferent to become much different.

And we run the risk of ignoring our old friends if we concentrate our efforts toward courting new friends.

We must also, I think recognize who our friends are. Just as we put up with the bad habits of a good friend, so we need to learn to work with groups who may disagree almost violently with much of what we do, yet have some common goals. Remember—dividing is the first step toward conquering.

Now, then, let me turn to the question of media relations. One of the first attitudes that needs changing is that the media is an adversary. It's true, they can nail our hides and they can be cantankerous, unreasonable and downright obnoxious. But so can we. And, more often than not, if we get nailed, we deserve it.

Another common attitude that must change is that somehow the media can be used or manipulated. Administrators often turn to this fairy tale for comfort. It's possible to cultivate the occasional journalist and make him a pet, but generally that kind of person doesn't have much credibility anyway. I'd rather deal with strict professionals who believe in the ethics and principles of journalism than fawning lackeys who are hard for anyone to swallow.

Yet another attitude to change is that the media owes us something. They owe us nothing. We compete with every human activity for limited space. Many of those activities are at least as important to history as ours are. Many aren't—but try usurping the National Football League with stories about zooplankton reproduction.

Finally, let's kick out the attitude that our job is to make our agency look good. Our job is resource management and the reporting of it. If we do a good job of both, the agency *will* look good. If we don't then we deserve every bit of criticism the media can dish out.

If an agency is corrupt or inefficient, no amount of talented public relations or professional reporting will save it. It deserves to be destroyed and ultimately will be.

Less dramatic than outright corruption, but far more common, is the bureaucratic tendency to stonewall, weasel, evade, be incomplete with news, be slow to respond, obfuscate, or resort to puffery.

The solution to these problems is simple. Don't do it. But telling a bureaucrat not to do those things is like telling birds not to fly.

Recently I wrote an article for our magazine about Missouri's first bald eagle nest in more than 40 years. The one eaglet produced was taken from the nest because both parents had vanished. I tried to make the point that if, as had been suggested in both the public press and conversations with ornithologists, the parents had been shot, the two dead eagles represented a net loss, regardless of the public joy over the baby.

I had my wrist slapped by administrative memo for contributing to a poor public image of hunters. I had said nothing about hunters and no hunting season was open. Considering that eagle shooting is far too common, considering that Missouri spends a lot of money on gun safety training, on rewards for information leading to the conviction of wildlife violators, on outdoor ethics, and considering that problems don't go away if you don't talk about them, I felt and still feel justified in what I wrote.

It's rare to find this kind of reaction in Missouri. I understand the nature of the bureaucrat. I understand that political considerations, self-preservation, and keeping the surface free of waves all are powerful forces in the shaping of government communication.

But I maintain that if we all bend willingly to whatever special interests happen to be in play when we produce our material, we not only aren't doing a professional job; we aren't doing a job at all.

Professional ethics in journalism are fairly well-established, enough so that any outdoor communicator with a government agency should have firm ground on which to plant his feet and resist. You may not win. You'll never win every time and you might not even win much of the time, but maybe you'll win sometimes.

And maybe you'll get a bit of grudging respect for sticking to your guns, an acknowledgment that perhaps honesty is the best policy.

If no one challenges unnecessary government secrecy, then it thrives and grows, like a cancer. Perhaps we lowly, underpaid, unappreciated news people can, by operating in a professional manner, by insisting on adherance to journalistic ethics, act as a sort of chemotherapy to bureaucratic nonsense. We may not cure the disease, but perhaps we can help to control it.

Now, then, as far as what you, as administrators, and you, as communicators, can do to reach the millenium, that Shangri La of conservation where everything will be wonderful, here are my suggestions:

1. If you are an administrator, hire professional news people and allow them to do a professional job. Look to the newspaper business for good writers with a flair for the outdoors, rather than to the biological community. There are far more writers who can communicate biology than there are biologists who can communicate it.
2. Strive for complete honesty in reporting. If you administrate, keep your information people informed and let them use their good judgement. If you communicate, do it honestly. Get caught in a lie by a newsman and you're dead.
3. Concentrate on real news or features—not puffery. Puffery—self-serving material—not only won't be run, but it will alienate the media.
4. Present your messages in usable form, regardless of the type of communication.
5. Maintain personal contact with news outlets. Know your audience (and the communicator's audience is editors and news directors, not the administration nor the general public). Administrators who appear to be human beings will receive a far more sympathetic treatment by the media than stiff-necked bureaucrats.
6. Be thoughtful. Go the extra mile for the media. You can't buy them, but they are human enough to appreciate courtesy and consideration. And any given story can be slanted easily pro or con by a good newsman who still will be able to defend its complete objectivity. I'd rather he slanted it my way.
7. Don't try to defend the indefensible. If you are a vulnerable position, make the best of it. Don't try to hide or soft-soap it; you'll make it worse.

I am not naive enough to think that professionalism is going to become the norm in resource management. Not as long as political appointees are chosen more for their loyalty to the elected boss than for their concern with environmental or resource matters.

But I've seen improvement in my few years in the field which gives me hope for continued improvement, for a gradual climb toward professionalism.

If the professional approach can't start from the top down, the way it logically should, maybe it can work its way up from the bottom. After all, the end result is what counts, not how you get there.

Thank you.

A Professional Approach to Conservation Education

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Introduction

The eminent conservation philosopher, Aldo Leopold, defined conservation as a state of harmony between men and land. Leopold admonished the repeated pleas for "*more* conservation education" as a viable solution to each new resource dilemma. His concern was with the content or quality of conservation education, not its volume (Leopold 1949).

Later, Ernest Swift (1961) reiterated Leopold's concern, writing on behalf of the National Wildlife Federation. Swift stated:

> There is no question that education is a strong force to forestall ill-advised and unwarranted change, as well as to promote sound and intelligent planning for the future. Resource education should not be a heterogeneous mass of material crammed into the minds of people like force-feeding a Christmas goose with noodles.

So much for sound advice, sometimes as easily ignored as assimilated. No sensible person can refute the value of educational quality in a democratic society. No sensible conservationist can deny the value of quality conservation education programs. However, a philosophical fork in the road seems to lead conservation organizations down dissimilar trails of content and methods in conservation education.

Missouri's Formal Approach to Conservation Education

People learn in a variety of ways. They learn by reading, observing, doing and listening; they also learn from experience and examples offered by others. Thus, education in America really consists of both formal and non-formal components.

Since 1941, the Missouri Conservation Commission has consistently supported a formal conservation education program through the established system of public, private and parochial schools. Our Commission has always insisted that its staff of conservation educators be trained professionals with actual instructional experience. The Department doesn't believe in assigning fisheries biologists to manage timber stands nor foresters to develop curricular materials for professional educators. Fourteen Conservation Education Consultants are assigned throughout the Show-Me state. Their primary assignment is to provide educational services to all schools, colleges and universities in their districts. These educational services include program materials, audio-visual aids, and consultation with professional educators. One example of program materials is the Department's award-winning K-8 Program, currently provided to approximately 13,000 elementary teachers.

Program Content

The content of the Missouri Department of Conservation's formal education program is based on the interdependence of all resources. Our state constitution charges the Conservation Commission only with responsibility for forest and wildlife resources. However, the Commission has always recognized the dependence of these resources on the land and has always insisted that our formal education program focus upon *all* resources associated with forests and wildlife. Our conservation education program is based on ecological concepts and a philosophy of wise resource use. Our goal is to instill this philosophy in Missourians along with an ecological conscience; or, in Leopold's words, a "land ethic."

In developing materials for Missouri schools, we must maintain a constant vigil to avoid the pitfalls common to many conservation education programs. Some of these pitfalls include:

1. confusing public relations programs with education,
2. developing materials that are impractical in today's classrooms,
3. placing too much emphasis on "nature study" and too little on the *impact of people* on natural resources,
4. generating so much material that we are guilty of agency "over-kill,"
5. providing program materials that do not mesh with existing school curricula and
6. losing sight of our goals and objectives in a flurry of activities and material development.

One of the strengths of the Department's formal education program has been its long-term continuity. This continuity has enabled our field staff to earn the respect of professional educators throughout the state. School personnel know we take our mission seriously and they treat our programs and staff members accordingly. Fads in education come and go but the Department's formal education program has been a constant in the shifting sands of educational change. We've never oversimplified resource issues to make them educationally "easy" or "fun." We've been guided by Leopold's admonition: "In our attempt to make conservation easy, we have made it trivial."

Program Methods

Practical, effective methods are essential to the success of any conservation education program. Since 1941, our Department's formal education program has stressed infusing conservation concepts into *all* appropriate subject areas of the school curriculum. Conservation is not a school subject, it is, or should be, a way of life. Therefore, our approach is to demonstrate to teachers and school administrators methods by which conservation becomes the "curricular common thread." A common thread which stitches the various curricular areas together into a comprehensive fabric of related subjects, ideas and issues. Natural resource problems are not solely biological; their import is equally significant to students of social studies, economics, political science, art, music and literature. Perhaps Ernest Swift (1961) said it best over twenty years ago:

> Conservation education should start with the small child and should relate to his daily living habits to instill in him an awareness of the problems. But above all, conservation education should create a reverent attitude for resources and then a deep sense of individual responsibility will follow.

Human population growth has reduced Missouri's wildlife habitat and forest acreage and has dictated changes in our methods of reaching youngsters. Now we spend less time addressing students directly. Our major instructional efforts today target both pre-service and in-service teachers through a variety of college credit courses and workshops. This "multiplier" approach maximizes the impact of our small staff while preparing teachers to infuse conservation concepts into their curriculum on a regular basis. There's probably a five-dollar word for this approach listed in some obscure Ph.D. dissertation. In Missouri, we consider this "working smarter, not harder" . . . or, good old "horse sense." This approach could not succeed without an adequate field staff to carry out follow-up contacts and support services to teacher trainees.

Program Effectiveness

The effectiveness of our formal conservation education program must be viewed in the context of the Department's total education effort. All Department personnel share a commitment to the non-formal component of this total effort. The Department's message is delivered with equal zeal to the Ozark "rock" farmer, the college professor, the St. Louis sophisticate, and the elementary classroom teacher. Viewed in this totality, the formal education component has made a significant contribution to the overall effort. Dissenters might hasten to comment on the numerous threats to Missouri's natural heritage. But conservation education efforts must be judged by the battles won, not lost, for we are the perennial underdogs. We should remember a statement by Ernest Swift (1961): "The true conservationists must be lovers of lost causes, or they won't persist. In not admitting a cause is lost—the cause is often won."

We've persisted and won some battles in Missouri by not admitting the cause was lost. The educational efforts of all Department personnel have reduced intentional forest fire sets and have supported wildlife restoration programs. These efforts aided Missourians in their decisions to stop the debacle called the Meramec Dam and to vote for increased funding for wildlife and forestry programs. The Department's Conservation Education Unit is proud of its role in this total effort.

Future Programs

The past is history and the present will become so tomorrow. What about future conservation education programs? The Missouri Department of Conservation's formal education program cannot rest on past laurels. The time is growing short and the issues are too important. Currently under development are new programs designed to increase our impact on Missouri youth. An Early Childhood Program soon will be launched to address the reality that many attitudes are formed before a child enters grammar school. A new Secondary School Program is being developed for specific curricular areas. A non-academic youth program, designed to strengthen the conservation efforts of existing Scout and 4-H organizations, is also being considered.

Conservation professionals cannot afford to wait until today's youth reach maturity . . . the time is growing short and the issues are too important. Perhaps we all should redirect the emphasis of our non-formal education programs. Perhaps we should spend less time addressing the already converted, be they sportsmen or other outdoor enthusiasts. Perhaps we should spend more time attempting to educate the disinterested, particularly those in positions of power. This will require the development of specific programs and materials for professional, business and religious organizations.

As we evaluate our professional approaches to conservation education, perhaps we should consider the interstate cost-sharing of educational material production within similar biotic regions. This regional consortium approach could result in substantially lower material costs to all member agencies and organizations. The public interest would seem to dictate this approach in the best of economic periods.

Finally and most importantly, perhaps conservationists should join professional educators in a mutual concern for the quality of education in general. We must do so as voters, taxpayers, and parents if we truly share Leopold's concern for the quality of conservation education. To do otherwise is analogous to expressions of concern about wildlife conservation which sometimes ignore the consequences of habitat loss.

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The Changing Face of Conservation Information

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Since 1977, when a conservation sales tax of one-eighth of one percent became effective, the Missouri Department of Conservation has found itself with a substantially broader constituency. Previously, our paying supporters were primarily hunters, fishermen and trappers, but with every citizen paying a sales tax, funding support became a lot broader . . . and so did expectations.

The Missouri Department of Conservation, like most other wildlife agencies, had not ignored the non-hunter or angler. Most wildlife agencies have been involved in some measure in programs for nongame species. Many of their facilities are used heavily by non-license-buying citizens. This is true in the Show-me state and everywhere else. Yet, our main thrust in all programming had to be for those who paid the bills. Now, with this broadened funding base, we truly became an agency conserving all wildlife and forests. This had a decided impact on all our programs, and the Information Section was deeply involved.

Taking on nongame wildlife management, endangered species preservation, natural areas and many services to the public was not really new to us. But the scope of these activities increased dramatically once the additional funding became available. From the regular divisions of wildlife, fisheries and forestry came a demand for many more informational tools to reach the new publics. It was Information's job to assist them. From newly-created Natural History and Land Acquisition sections and a considerably expanded Education Section also came demands.

We soon became editors to the Department in ways we never dreamed. The expanded conservation education program we call K-8 (Kindergarten through grade eight) required the output of teaching materials that far exceeded putting out the monthly magazine. That meant additional editing and artwork and more demand on our printing facilities. Creation of an Outdoor Skills Education unit brought new teaching guides, and other printed materials, all of which passed through the Information Section—serving as editors, artists or printing procurement agency.

We had been producing motion pictures and sound/slide shows for use by Department personnel, but the pace of this activity increased dramatically, also. In the past five years, for example, we have produced 19 different sound/slide shows, covering things like "Wildflowers and the Sun," "Return of the Fur Traders," "Operation of Slide Projectors," outdoor photography, steel shot, backyard wildlife, toads and frogs, "How to Prepare a Slide Show," and natural land divisions. There currently are five more shows in preparation.

Another area of great expansion in order to reach the new audiences has been in exhibits. Previously, we had been responsible for exhibits at a couple of sports shows and the state fair and four regional fairs. With the advent of the conservation sales tax, our exhibits efforts have burgeoned to where last year we played eight sports and travel shows, 28 county fairs, in addition to the state fair and four regional fairs, major farm shows at the American Royal in Kansas City and the National Future Farmers of America convention, plus 15 other showings at such things as farm field days, teachers' conferences, various shopping malls and special Prairie Days. We built 45 exhibits to meet these needs: nine portable, 34 small and two for permanent installations. These activities, plus slide shows and publications, have created greatly increased demands for photography.

We continue to exploit radio, both with public service spots and with a regular daily broadcast from the office. The latter is a three-minute broadcast on various outdoor topics that is taped and put on a continuous cartridge playback recorder that meets NAB standards. We have an in-WATS line that radio stations use to call in and tape off the show for rebroadcast. About 80 radio stations use the service daily, but on Thursdays and Fridays through the summer, when we air fishing conditions reports, the use jumps up to well over 125 stations. Some 40 field personnel have their own local radio shows as well, greatly augmenting Information Section's efforts.

We have two regular television shows conducted by Department personnel and issue TV public service announcements from time to time. They get good usage, because of subject matter and professional quality.

Last year we issued 54 regular news packages, each of which included at least two photos, plus 34 special news releases. This is traditional, and clipping surveys show that we get free space in newspapers valued in the many thousands of dollars. Again, because of subject interest and professional quality.

We still maintain a library of motion pictures and slide shows that schools and clubs can borrow. Our emphasis is shifted slightly from traditional hunting- and fishing-related films to those on natural history subjects and outdoor ethics. We currently have 1,200 prints of 150 titles in motion pictures, plus 45 slide shows in 13 titles. Last year we sold 76 films and 17 slide sets to other conservation agencies and schools.

I mentioned earlier that stepped-up Department programs fostered a greater demand for publications of all types. Most of these pass through Information's hands, from P-R and D-J reports, technical bulletins, leaflets and brochures of a "how-to" nature and public-use area information, to forms and regulations for special seasons.

Add to these, our 32-page monthly magazine, *The Conservationist,* which is the nation's largest-circulation conservation magazine with over 300,000 subscribers, including 11,000 non-resident and 6,000 foreign subscribers, plus annual production of the *Wildlife Code*—over one-million copies—and you can see that we are heavily into print media.

To handle these, we have added editorial and art personnel to the staff, and have our own typesetting facility. We do paste-ups, make our own printing plates, and have four presses to handle the printing. The print shop includes power stitcher, paper cutter, folding machines and collators.

We got into book-publishing as early as 1944, with *The Prairie Chicken in Missouri* by C. W. Schwartz. In 1959 we jointly published *The Wild Mammals of Missouri* with the University of Missouri Press. Since that time we have published and sold 366,000 copies of eleven different titles. These books are sold on a cost-recovery basis, as information guides for the general public to conservation and the outdoors, and as contributions to science. Recent titles include: *Missouri Wildflowers, Wildlife Drawings, A Field Guide to Missouri Ferms, Missouri Orchids, Fishes of Missouri, Missouri Hiking Trails, Missouri Ozark Waterways.* In press are books on Missouri butterflies, on Missouri naiads (freshwater mussels) and a guide to mosses and lichens.

I mentioned our printing shop in connection with publications, but we also print many other items for the Department, which enables us to effect some cost and time savings. Hitherto, when printed material was printed outside the Department on bids, it required ordering large quantities in order not to run out. Such items often become obsolete, resulting in waste. Paper is cheaper to store than finshed publications or forms, so we now print only enough to fill our immediate needs.

Last year, our print shop handled 4,600 jobs involving 13 million impressions.

Besides the other activities, Information Section handles all the Department's mailing functions. These include regular letters, plus management surveys addressed to many thousand citizens. Some idea of the magnitude of mailings may be obtained from our postage budget last year—$306,000.

When I came abroad the Missouri Department of Conservation in 1951, Information personnel numbered seven people. Immediately prior to the passage of the conservation sales tax with its broadened programs resulting, we numbered 22 people. Today, we total about 35, including temporary help. It takes many skilled hands to turn out the volume of high-quality informational material the public has come to expect from us. In the immediate future, with its squeeze on adding personnel, but no slackening of the demand for filmed, drawn, written and spoken information, we're going to have to work a lot smarter. This year, we hope to add word processors to our arsenal to help us do that. We are optimistic that we can not only keep up with demand, but continually make our products better and more useful to the Department and the public we serve.

Interpreting the Wild World

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Our wild world is a big place, a place of endless marvels. National and state polls have shown a tremendous public interest in all things of nature. Our opportunities for effective interpretation of this scene are limited only by our own ability and initiative. Professional training in land or resource management does not automatically make us good interpreters. We also need to be keen observers both of man and nature. The skill of an interpreter comes into play when we can transfer these wonders, curiosities, or simple truths from our own mind's eye to that of our audience through both the written and spoken word, photographs and illustrations. We need to transfer the "feel" for the subject, and this may take an appeal to all the senses. Another motivator for interpretation is the realization that our real peer group is the public; the people who pay our salaries, buy our products, vote and control the ultimate fate of the resources in our charge.

What is an interpreter? Each of us may have our own ideas, but the definition I like best is Yorke Edwards' when he says, "A good interpreter is a sort of Pied Piper, leading people easily into new and fascinating worlds that their senses never really penetrated before. He needs three basic attributes: knowledge, enthusiasm and a bit of the common touch" (Edwards 1965).

I like to think of interpretation as selling appreciation of natural resources.

Under Missouri's expanded conservation program, where every taxpayer is a constituent, our Department has given increased emphasis to interpretation, as well as information and education. Interpretation has become a major objective where we seek to create better public understanding of our natural world and increase the opportunities to enjoy it. We recognize that interpretation is a Department-wide function and a part of every employee's job.

However, responsibility for coordination and direction of interpretation has been assigned to our Natural History Section, which, incidentally, also has responsibility for nongame wildlife, endangered species, natural areas, and urban wildlife. Selling appreciation for cute and cuddly critters, pretty flowers and majestic trees is easy, but you have to try harder when it comes to bats, snakes, rats, chicken hawks (both the big and little kinds), chiggers and weeds.

As a Section we work closely with both our Education and Information People too. We supply a variety of materials to our Education Section for their use in the K-8 school program. In cooperation with the Information Section we develop publications and exhibits and regularly contribute articles for our widely read magazine, *The Missouri Conservationist.*

We recognize that there are many audiences out there and that there are other ways to reach them with interpretive messages. We do try to lever our program by working closely with all elements of the mass media. For example, our St. Louis Urban Biologist, David Tylka, had had feature articles in the St. Louis *Post Dispatch* and also does regular radio spots. Joseph Werner, our Kansas City Biologist, similarly has worked with the TV folks and was instrumental in getting national TV coverage on one of our Eagle Days via the "P.M. Magazine" program.

We supply publications, photographs, slide shows and other materials to our field people, and these conservation agents, foresters and biologists do a tremendous job of telling the story of our wild world.

We work closely with the interpretive naturalists employed by other government agencies and private organizations. This cooperative effort is a two-way street and we share both time and talent. Collectively we do a lot better job of carrying the message than either of us could do alone. All too often naturalists are on organizational sidings, out of the main stream of traffic. They do need support and reinforcement. They also need recognition for the very real importance of their jobs.

Within the Missouri Department of Conservation we have five interpretive naturalists and one naturalist coordinator who work at interpretation full-time. Three of these people are assigned to metropolitan nature centers, but they also have interpretive responsibilities at the other Department properties in their areas, and they all do off-site work with organizations. One naturalist is assigned to an interpretive center at our Shepherd of the Hills Trout Hatchery. This facility is in the heart of a major tourist area and gets about 115,000 visitors each year. Our Rockwoods Nature Center in St. Louis County has a visitation of 133,000. We have a naturalist too at our central office who provides guided tours for about 7,500 people each year. On the average, our naturalists give direct service (guided tours or talks) to about 10,000 people per year. Indirectly of course, they reach many more through self-guiding trails, exhibits, pamphlets and canned slide shows.

We have been very successful at organizing special interpretive events. In-house we call these Natural History Spectaculars, but actually we only organize them. People from every section of the Department of Conservation and many outside volunteers make them successful. These interpretive events include Eagle Days, Prairie Days, A Day in the Forest, and Owl Prowls.

We borrowed our Eagle Day idea from Tennessee and a project they had at Reelfoot Lake. It was a natural for us since Missouri regularly winters one of the largest populations of eagles in the lower 48 states. The Squaw Creek Refuge in northwest Missouri, for example, may have as many as 300 of these majestic birds at peak periods. Despite this, most Missourians had never seen an eagle and had no idea they were so close. (Of course, the birders knew.) We had the eagles and we had the people. So, for the last five years we have had three and often four Eagle Days each winter. About 5,500 people per year attend these weekend events. We intentionally have these in four different regions of the state to provide maximum attendance opportunity. These have been so popular that we have had to require reservations to handle adequately the crowds in restricted indoor space. It takes 16 to 20 interpreters or guides to handle these events. Programs are conducted continuously throughout the day. As people arrive they are directed to a building for orientation. There they can view exhibits on the life history, range, and status of eagles. Mounts of bald eagles and golden eagles are used for identification. At regular intervals we show the eagle film, *Bird of Freedom;* then a slide talk on eagle rehabilitation, propagation, and restoration (as a nesting species) is given by Paul Price of the Dickerson Park Zoo in Springfield, Missouri. This is climaxed by the appearance of Omega, a fist trained eagle. She very well may be the most photographed eagle in the country and is certainly the piece de resistance. The visitors are then released in groups and directed or led to various viewing spots to see wild birds. We furnish and man spotting scopes and have interpreters on hand to show and tell. Portable radios are used to keep track of the eagles and to direct crowds to new locations. As far as we know, everyone at our Eagle Days has seen a wild eagle, and it is not unusual for them to see from 30 to 100 birds.

Despite some really awful weather and two total snow-outs, the participants have been very pleased and enthusiastic. We have had people from all walks of life, from nursing babies to octogenarians, rich people in Cadillacs and poor people in beat up pick-ups. Many families participate. Some have come from as far away as Virginia to attend. Our original intention was to reach the non-birding people who had never seen eagles. Our polls showed that for 51 percent of the people, this was indeed the case. One-third of our audience were hunters, two-thirds were fishermen, and 80 percent fed birds at home.

We professionals have developed categories for consumptive and nonconsumptive users and game and nongame wildlife, but people really don't fit these molds and neither do critters.

Perhaps most important from our standpoint was the fact that 64 percent of the audience rated the experience as, "very enjoyable," and an added 32 percent said it was, "one of the most enjoyable wildlife viewing days I've every had."

I think this attitude also explains why we have had so many dedicated volunteers serve as interpreters. These people give up weekends and freeze in miserable weather. But there is great personal satisfaction—a real sense of achievement. This, by the way is characteristic of our other outdoor spectaculars, too.

Our owl prowl follows a similar agenda. Participation is limited to 100 people each in two one hour sessions. These were held at nature centers in the metro areas and were locally organized by urban biologists. Films and live birds from rehabilitation centers are used in education programs and then the folks, in small groups, are led to the woods, where we talk to wild owls and sometimes call them up close enough to view.

Incidentally, I should mention that local Audubon Societies are often co-sponsors of both Owl Prowls and Eagle Days and that the U.S. Fish and Wildlife Service participates freely as a sponsor at the two events held at federal refuges.

Our Prairie Days and Days in the Forest feature ecosystem interpretation rather than single species. The Missouri Prairie Foundation has been a co-sponsor of Prairie Days. These are strictly outdoor events. At a central staging area we have specialist "talkers" who give continuous but synchronized 20 minute talks on the herps, birds, mammals, insects and fungi characteristic of these habitats. For these we use live animals, mounts, skins, photos and/or preserved specimens. We try to arrange for small groups of about 25 at individual talks to allow for close hands-on types of communication.

Eventually "walkers" again take small groups out for guided walks across the prairie or through the woods to look at grasses, flowers, shrubs or trees, and to see wildlife as it appears. Herps, insects, and birds are commonly seen, and we have seen deer and coyotes.

You may be interested to know that one of the best talks at the Day in the Forest was given by Rich Wehnes on forest and fish. He did a fantastic job on relating the importance of trees to fish and streams.

We tie people through history and culture to these ecosystems in several ways. Sunbonneted lassies (a la "Little House on the Prairie") have a story telling session about pioneer experiences. This has been a real grabber. It originally was designed to appeal to kids, but it has been equally well received by adults.

For one Prairie Day, we had a chuckwagon with cattle drovers in costume to tell about the old Texas cattle drives to the railheads. The first one of these, by the way, was to Sedalia, Missouri. A feature at the end of the trail is the lodge (tepee) of mountain men on a trapping trip to the Shinning Mountains. They came equipped with full regalia, peltries of various sorts, and their own real live-in squaw. The importance of the fur trade in Missouri is emphasized, and we also put in a pitch for the Osages who once ruled this land.

We accommodate about 850 people at each of these "Days." And we have had up to 30 volunteers as "talkers, walkers and actors." The real secret in making these outstanding interpretive events is to keep the ratio of people to guide low so that they become personalized events. We also have magnified all of these programs with excellent media coverage.

We would like to expand these interpretive spectaculars to Days on the Glade, Marsh and Swamp. And we want to have our next event as A Day by the River. Finding suitable places for these events is not as easy as it might sound. We can rent port-a-potties; that is not the problem. Finding safe parking for 200 cars is another matter. We have to be able to accommodate crowds, and good areas with this attribute are not plentiful.

I want to mention one other new development that I believe will have great potential for the wild world interpretation. Our Department recently purchased an outstanding tract of 1,500 acres (607.5 ha) in the Shephard of the Hills country of the White River Ozarks. We hope to manage this tract as an interpretive experimental area. The land features scenic glades, forests and stream frontage on Roark Creek. It is a fine area by itself, but what makes it unique is the fact that up to 6-million people per year visit the area and 2-million of them visit a theme park called Silver Dollar City that is just down the road a few miles. Many retirees in the area possess a wide variety of skills and could be developed into our important docent group. We do plan on installing a Travelers Information Station radio to provide interpretive messages to the often bumper to bumper tourists. And we will have an opportunity to try and measure response for many other interpretive techniques.

We need to remember that the wild world with which all of us deal every day is a constantly new and fascinating place to John, Jane and Junior Doe. Opportunities for interpretation are endless. In 1781 Goethe wrote these timeless words, "The spectacle of nature is always new for she is always renewing the spectators. Life is her most exquisite invention, and death is her contrivance to get plenty of it."

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When Learning Becomes Fun

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Introduction

How we best learn has intrigued educators for aeons. But ask a youngster and the response will probably come quickly—"When it's fun!" Learning becomes more fun when it relates to our personal lives and our everyday environment and when we become actively involved in the process.

Outdoor education has a somewhat unique opportunity of rather easily making learning fun. Because youngsters are frequently curious about the natural world and because they enjoy being outdoors, it is easier to capture their attention and instill a message.

The Message

The message we instill is extremely important and how we get it across to our audience can take many forms. In outdoor skills education, our message focuses on how to use the resource skillfully and responsibly.

In most fish and wildlife agencies, hunter education has been the primary, and sometimes the only, educational effort our departments have to offer. The results of this program are evident. Each year 700,000 young people are certified as safe hunters in the United States and Canada, while statistics show the incident of hunting accidents decreasing.

In Missouri, however, the traditional hunter education training was expanded in 1976 to include many more activities that use the state's fish, game, and forestry resources—activities such as fishing, trapping, backpacking, archery, canoeing, the shooting sports, outdoor cooking, caving and others. These subjects fit quite nicely into a school curriculum in a variety of classes. The response to our expanded program has been overwhelming. Several junior high and high school teachers have said, "It's the first class to fill each year and there isn't enough room for all the students who want to take the course."

Through our expanded curriculum offerings we are teaching wise use, responsible behavior, safety, skills and, at the same time, we are able to spread our message of conservation, wildlife and fisheries management, and proper resource use. Primitive skills, black powder, and early firearms development are taught in history classes; archery, canoeing, fishing, and shooting sports in physical education; outdoor cooking in home economics; map and compass in math.

Through all subjects we promote the teaching of outdoor ethics. In some schools our outdoor ethics program is a prerequisite to taking students on outdoor education field trips.

The Audience

Thus far, I have mentioned only youth as an audience for our message. They are a natural target in education programs, but they are not our only target. As we plan our programs, we do not overlook adults—sportsmen, nature lovers, senior citizens, youth leaders, parents. These people buy licenses, pay taxes and vote. They also can have fun learning, and some of them have more leisure time.

There is one audience I want to be sure to single out—it spans all ages and the work we have done with this group has had some of the most rewarding results. I am referring to handicapped and developmentally disabled individuals. Missouri has been a pioneer in some respects in this area. We have adapted our subject areas to the needs of handicapped groups. Special programs have provided recreational opportunities in fishing, shooting, camping and other outdoor activities. Through clinics and workshops we have trained teachers in how to adapt equipment and teach skills to their handicapped students.

The Delivery System

How do you reach a broad range of people with a broad-based message? In Missouri, we have taken a broad number of approaches.

Education Materials

Schools have been a primary focus. When working with teachers, it is important to have something to hand them. Give them in a useable form what you want them to teach. Working with the state department of education, we are developing a series of instructor modules. The modules are designed so they can be used individually or combined to teach a more extensive course. Each module has the information needed to teach the subject: lesson plans and activities, a glossary, bibliography and student handouts that can be reproduced. It has not been our intent to re-invent the wheel, but rather to digest available publications and materials on a given subject, condense the information, add lesson plans developed by experienced teachers and turn out a publication containing every facet required for a classroom instructor to teach the course with minimal preparation.

The modules are developed in various series—outdoor living skills, shooting skills, archery skills, primitive skills, casting and angling skills and aquatics skills. (See Table 1 for a list of the modules in each series.) When the modules series are completed, there will be 30–35 separate manuals. A junior high or high school teacher will be able to put together a semester or year-long outdoor education course using the materials.

Where appropriate, each of the modules has a section on how to adapt the skill to the developmentally disabled. In addition, however, we are planning to produce a separate module entitled "Outdoor Skills for Special Populations." Hopefully, this will help open up a new world of outdoor activities to people whose normal lives are constrained by disabilities, aging or other factors.

Because of the cost, we have not tried to produce student materials in each of the subjects. We have produced, however, a student hunter education manual and Kids Fishing and Conservation Caring books. They have been extremely popular and are getting our message into homes.

Workshops/Short Courses

If you want your message taught and taught correctly, you may need to train people. This is especially true in outdoor skill areas. Our education field staff

Table 1. Outdoor skills education modules.

Module is defined as a self-contained, independent unit of a planned series of learning activities designed to accomplish certain well-defined objectives.

Use:
1. Can be used individually or combined in a variety of different sequences
2. Can take one class period or several weeks
3. Incorporates a wide variety of media and activities
4. Leaves selection of approach up to the teacher
5. Incorporates active student participation

Proposed Modules:

Series	*Modules*
Outdoor Living Skills	Basic Principles Environmental Emergency Preparedness Backpacking Backpack Cookery Map and Compass Camping Campground Cookery Caving Outdoor Photography
Shooting Skills	Firearms Safety Hunter Education (Instructor and Student) Basic Rifle Basic Pistol Basic Shotgun and Shotgun Games Black Powder
Casting and Angling Skills	Casting Equipment Spin Cast Fishing Fly Fishing Fly Tying Spin Fishing Bait Cast Fishing Making and Repairing Fishing Equipment Fishing Without Rod and Reel
Archery Skills	Basic Archery Bowhunting Bowfishing
Aquatics Skills	Basic Canoeing Water Safety and Survival
Primitive Skills	Trapper Education Primitive/Pioneer Skills Wild Edibles

The value of the modules will be their flexibility to be used for a brief or extended period of time, their ability to be used separately or combined, and their detailed methods of how to teach outdoor skills in a variety of situations (classrooms, camps, youth groups and clubs).

conducts workshops and short courses to train teachers and youth leaders how to teach the various subjects. We certify instructors in some courses, such as hunter education. In the field of outdoor education, certification programs may become increasingly more important. Fortunately, there are organizations already offering certification in some subjects, such as the National Rifle Association for shooting sports and the American Red Cross for water safety.

Seminars

If given the opportunity, many people will take advantage of a chance to learn—especially if it is to learn more about something they particularly enjoy. This has been evident in the popular response to our deer hunting and turkey hunting seminars. Such seminars or clinics provide an opportunity to reach a specialized audience to better educate them about their particular sport. Participants are given hunting tips, safety reminders, information on equipment and a chance to sight-in or pattern their firearms.

Ranges/Training Centers

Since the Pittman-Robertson Act was amended to make funds available for hunter education and/or range development, the Missouri Department of Conservation has built 43 ranges—both firearms and archery—around the state. The ranges have been one of the most popular programs among our constituency. They also seem to have the effect of cutting down firearm vandalism on our properties, and because they concentrate shooting activities, our areas are safer. Many of the ranges are not manned; therefore, maintenance costs are low.

Our range near urban Kansas City was developed as a training center. In addition to serving the public as a shooting range, this facility has a classroom. On the surrounding park area, leased from the Jackson County Parks Department, we are planning to develop an archery field course, hiking trails, and primitive camping sites and use the land for other educational programs. Both the county and the Department benefit from this type of arrangement.

Urban and Therapeutic Fishing Programs

Of all the outdoor skills, fishing probably attracts the most followers. It is an excellent form of therapy or recreation for specialized groups. Urban fishing programs are offered in St. Louis and Kansas City each summer to benefit inner-city youth. Cooperating with city hospitals, we also have provided opportunities for physically and mentally handicapped youth and adults to fish in the ponds that have been stocked for the urban fishing programs. A small amount of equipment, some bait and one or two employees have provided immeasurable delight for hundreds of youth and adults.

National Hunting and Fishing Day/Wildlife Week

Hopefully, we never miss an opportunity to get our message to the public—to educate them in any manner, no matter how subtle. Special observances such as National Hunting and Fishing Day and Wildlife Week are a good chance to set up exhibits in shopping malls, sponsor fairs, run special programs and mostly just visit with people. It is an opportunity to communicate with people not necessarily devoted to our cause.

Summary

Whatever educational efforts you undertake, they should be broad based and flexible. Offer as many different ways of teaching the message as possible. If you are working with teachers or youth leaders, put information in their hands. If possible, provide training to reinforce their confidence in teaching the subject.

When learning a subject becomes fun, teaching it also becomes more enjoyable. Those of us who are promoting outdoor education messages have a product the public wants. There is a renewed national interest in the environmental movement, spurred by people who are spending more time outdoors and seeing firsthand what is happening to the environment. Schools are offering more programs in both outdoor and environmental education. State agencies such as ours can either take a leadership role in the movement and assert some influence, or we can take a back seat. The results of not getting involved may be more serious than we realize, for our youth are getting messages from sources that differ with our philosophy.

The Missouri Department of Conservation has made education one of its highest priorities. We have been fortunate to have administrative support for the type of programming I have described to you. We have also received support from the state's Department of Elementary and Secondary Education. In Missouri, the Conservation Department is taking the lead in curriculum development for outdoor skills and conservation education.

You are not alone in your efforts. Help is available through other agencies, state universities and national organizations. Missouri's materials can be reprinted or adapted to your state's needs. You may be able to recruit university faculty to teach at workshops or write materials for you. Student interns are frequently searching for a semester's project. Many national organizations publish a host of materials, teaching aids and program ideas. Private clubs may want to take on an educational project and merely need some advice. Funding or lack of personnel do not have to cripple your efforts in this area; education is generally more a matter of priority.

As a final thought, I would encourage you in everything you develop and teach, be sure you instill the ethics message of responsible, respectful behavior. Education is the key. If we do not teach people to use the outdoors responsibly, our environment, our recreational pursuits and the future of hunting and fishing will suffer the consequences of our neglect.

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Wildlife and Fish Management in the Forest Service: A Goal Oriented Approach

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Introduction

The U.S. Department of Agriculture, Forest Service, has been entrusted by Congress to manage habitats for over 3,000 vertebrate species of fish and wildlife on more than 191-million acres (77.3-million ha) of public land. The broad Forest Service charge for wildlife and fish management is: (1) maintain viable populations of all plant and animal species and to maintain their same general distribution; (2) promote recovery for threatened and endangered species; and (3) provide for increased carrying capacity for species in public demand such as deer, salmon, and turkeys.

The goals and objectives to accomplish this charge are established nationally in the Forest and Rangeland Renewable Resources Planning Act (RPA) program.

They are more specifically defined in individual National Forest Plans completed under the National Forest Management Act (NFMA). The National Environmental Protection Act, "NEPA," guides Environmental Impact Statements (EIS) covering Forest Plans and Environmental Analyses and Statements covering implementation projects such as habitat improvement.

With these goals encompassing this much land and so many species, a systematic process had to be developed if the goals were to be realized. The process is complicated by the need to update the RPA program every 5 years, plus the need to accomplish planning on 3 future years, and track accomplishment in the current one. The Wildlife Management Institute in an evaluation of Forest Service fish and wildlife programs completed in January of 1979 recognized the same problem and recommended the development of sound goals and objectives.

In 1979, a Steering Committee was assigned the job of completing a project called the "Framework for Managing the Fish and Wildlife on the National Forests in the 1980's" (Forest Service 1980). Under the Steering Committee, a framework was developed by task force of several teams of Forest Service personnel. Help was solicited and received from states. The framework that was developed provided a new approach to quantitative objective setting and attainment tracking at all levels in the Forest Service. The Framework was accepted by Chief R. Max Peterson in June 1980 and implementation began.

Wildlife Management Systems Used to Accomplish Goals

Before discussing goal setting and accountability, a discussion of how the Forest Service accomplishes fish and wildlife habitat improvement is necessary. The Forest Service has historically used two generalized wildlife management systems or concepts to accomplish "game management" and more recently to manage habitat for all wildlife. These systems are known as "habitat diversity" and "featured species." The National Forest Management Act introduced a third concept called the "Management Indicator Species Concept," which is presently being used.

Habitat Diversity

This approach provides for a variety of habitat components in a desired combination that will ensure fulfillment of the individual needs of all species. This is referred to as management for species richness, or habitat diversity (Evans 1974). A management program based upon the principle of "diversity" does not directly favor one species at the expense of another. A wildlife goal based on this concept requires establishment of a desirable mixture of habitat components that will provide the greatest diversity through time on a sustained basis. A management program to provide diversity would have as an objective a given acreage that would support a variety of species in different densities, dependent on the carrying capacity of the area being managed (Siderits 1975).

Featured Species

The featured-species concept is an approach to habitat management in which goals and objectives are set for designated species on a unit of land. Habitat requirements for the featured species are used to guide habitat improvement and to coordinate habitat management with other resources programs such as timber, range etc. Coordination of wildlife and fish with other resource activities and direct habitat improvement measures are specified, which are directed at meeting the needs of the featured wildlife species (Zeedyk 1974).

Featured species can be game species, threatened or endangered species, or species that have particular esthetic value. If the species to be featured are carefully selected and their habitat needs vary widely, then featured species management will also ensure habitat diversity. The result can be similar to management for species richness (diversity) (Thomas 1979).

Management Indicator Species

The Forest Service, today, is required by NFMA to manage habitat using the management indicator species concept. Selection of management indicator species is based on the need to maintain viable populations of all species, promote increased production of species in demand, such as those commonly hunted and fished, and recovery of threatened and endangered species.

Concepts from both featured species and habitat diversity are used to manage the group of management indicator species on a forest. The featured species concept is usually used for endangered and threatened species. For other species, both concepts are used in combination to ensure viable populations while providing habitat that will meet planning goals, such as increased elk habitat or increased anadromous fish habitat.

Setting Fish and Wildlife Goals

Aldo Leopold wrote in 1933 that "Game management is the art of making land produce sustained crops of wild game for recreation use" (Leopold 1933). This statement is still appropriate as we work to produce a mix of renewable resources from National Forests to best meet public needs. On National Forests this goal is achieved by: (1) manipulating habitat—a Forest Service responsibility—to produce some level of habitat for a desired species; and (2) managing animal populations—a state responsibility—to achieve a desired objective.

The Multiple Use Act of 1960 directed that ". . . the National Forests be managed under principles of multiple use and to produce a sustained yield of products and services. . . ." Congress, for the first time, directed that National Forests be managed for wildlife and fish.

State Comprehensive Plans

The first definitive fish and wildlife goals and objectives were established during the 1970s, in cooperation with the states, through Comprehensive Sikes Act Plans (P.L. 93-452). Management objectives in these plans, which cover all National Forest System lands, emphasized acres of habitat needed to meet species needs, generally game species. These plans are periodically updated and are still in use. They are implemented through Forest plans.

The 1975 Renewable Resource Program

The 1975 RPA Assessment and Program was the first major effort at assessing the forest and rangeland resources of the United States and developing of a Forest Service program to meet future resource needs. The wildlife and fish habitat management goal selected for the 1975 program was to: "Provide for species diversity and greater wildlife and fish populations through a substantial increase in habitat management."

National goals for populations of wildlife and fish on the National Forests were set in terms of an index, using existing population numbers as a base of 100. This index was established by species group (big game, small game, waterfowl, etc.)

The program projected the need to improve 26.3-million acres (10.6-million ha) for wildlife and 1.1-million acres (445,000 ha) improved for fish by 2020. Projected program costs and outputs (recreation use) were $41.2-million by 1980 to meet 15.1-million hunting, 23.7-million fishing, and 4.0-million nongame visitor days in 1980. How accurate were these projections?

As a result of the RPA and Sikes Act plans, the Forest Service budget increased from $4,731,000 in 1970, to $38,780,000 in 1980 with 15.8-million wildlife and 17.1-million fishing visitor days use reported. However, there was no systematic way to track the work accomplished and the benefits from that work, or to determine how closely the increases in recreation were related to the program. The method used was "best estimate."

Units of Measure Used in the 1970s

During the 1970s, objectives emphasized acres of habitat treated to meet specific wildlife needs. Acres treated, however, was not a useful measure of habitat improvements as they provide only an estimate of the total benefits to fish and wildlife. Acres "treated" subsequently evolved to "acre equivalents," to better reflect the habitat *influenced* by management actions. For example, it was decided, based on experience, that one water development for big game influenced the surrounding area for about a square mile or 640 acres (259.2 ha); for small game, the area influenced by a water development was 160 acres (64.8 ha), based on the reduced home range size and dispersed capability of the animals. The acre equivalents were 640 acres and 160 acres per water source respectively, which served both as an input (work unit) and output (benefit).

It was difficult for the public, Congress, and many people within the Forest Service to understand acre equivalents. Accountability was poor because they were difficult to measure. Reporting of acre equivalents resulted in an illusion of over accomplishment, while, in fact, habitat losses were occuring because actual investments were not keeping up with losses due to other programs and natural succession.

The Wildlife Management Institute Review

In 1977, the Forest Service recognized changes were needed and contracted with the Wildlife Management Institute to undertake a review of the organizational and management systems as they pertain to Forest Service fish and wildlife management. The Institute's report to the Forest Service, in January 1979 (Wildlife Management Institute 1979), made several recommendations related to planning.

One of the Institute's main concerns was that the Forest Service had not established sound wildlife and fish goals and objectives. Further, the Forest Service did not have a systematic way of accounting for fish and wildlife accomplishment in relation to goals that had been established.

The Strategy for Quantifying Fish and Wildlife Information

Developing Measurable Work Units and Outputs

In response to the Wildlife Management Institute Report, a Forest Service team, working on the Framework for the 80's, developed a proposal for measurable fish and wildlife work units and benefits or "outputs" from those work units. The work units and outputs were to be monitored at all levels in the Forest Service to determine if goals are being accomplished.

Work Units. The work units were "acres" treated and "structures" constructed that benefit habitat for specified fish and wildlife species. Both "acres" and "structures" can be found and measured on the ground, providing a means of accountability. Both acres and structures represent many different kinds of work, from seeding and planting to prescribed burning and from bird houses to fences.

Outputs. The units of outputs (benefits) realized from investment in various kinds of acres and structures (habitat improvement) are: (1) "habitat capability" (carrying capacity) expressed in number of animals or pounds of fish; (2) recreation in the form of "wildlife and fish user days," which includes hunting, fishing, bird watching, and other fish- and wildlife-related recreation.

Habitat capability is simply an estimate of the number of animals a given acre of habitat can support. For example, a 2000-acre (810-ha) deer habitat improvement project on winter range is designed to increase carrying capacity by 200 deer. This concept allows quantifying and tracking benefits for individual species (in this case deer) and species groups; it works for endangered species and fish as well. Using habitat capability rather than actual animal numbers addresses the states' concern that the Forest Service's responsibility is dealing in habitat rather than animals. In this example, we are talking about *potential habitat carrying capacity for 200 deer* rather than 200 deer per se. In making these estimates, it is realized that there are many factors that affect deer populations; however, Forest Service and state biologists make their estimate based on knowledge of each situation.

"Wildlife and fish user days" was selected as a measure to determine economic benefits and to provide units of measure that can be aggregated into one figure. Dollar values were developed, as a part of the RPA program, for the major categories of wildlife and fish user days for each Forest Service Region. In the previous example relating to 2,000 acres of deer habitat improvement, which cost $70 per acre and which increased the carrying capacity by an estimated 200 deer, an estimated, 1,500 wildlife and fish user days (WFUDs) per year were produced over the 20-year life of the project. The general value for each WFUD, as developed for the 1980 RPA program, is $20/WFUD, giving the project in this example a net present value of $115,000 at a 10 percent discount rate. The benefit-cost ratio is 1.8 to 1.

Setting Quantifiable Goals

The measurable work units and outputs were not available for the Draft RPA program document released in 1979. The final 1980 RPA documents, however, included the new quantitative wildlife and fish output goals that were to guide Regional and Forest Plans. These targets were identified by "habitat capability" expressed as a population index for selected national management indicator species.

The habitat capability goals developed for the 1980 RPA program, to be accomplished by 1995, are as follows:

Species/Species Group	Index*
White-tailed Deer	120
Black-tailed Deer	125
Elk	118
Mule Deer	120
Wild Turkey	133
Cavity Nesting Birds	100
Resident Trout	120
Anadromous Fish	130

*These indices represent the change in habitat carrying capacity by 1995, with the current (1980) situation = 100.

Implementation and Tracking of Wildlife and Fish Goals

The implementation of a resource goal takes several years before the result can be seen at the ground level. The key to ensuring implementation depends upon whether or not it can be translated into understandable units of work with definable costs. The information must be aggregated and disaggregated as it flows up and down in the agency, department, Office of Management and Budget, and Congress.

The diagram showing this information flow is called the "Forest Service Management Model." It allows wildlife and fisheries program managers to look at the entire Forest Service planning strategy.

The Forest Service Management Model is shown in Figure 1. Some key points to recognize are: (1) the arrows always flow both ways to facilitate feedback; (2) at any point in time we are simultaneously dealing with six or seven annual budget cycles and most of the boxes identified on the model.

Working Within the Forest Service Management Model

Long-Range Plans. Forest Plans respond to the RPA goals established in 1980. For example, a stated goals is: "to increase habitat capability of elk by approximately 18 percent (average national goal) by the year 1995." Each Forest Plan should determine the work units (acres and structures) and funds needed to coordinate other programs with fish and wildlife to accomplish the Forest's share of the RPA goals assigned by the Region.

Program Direction. Annual program direction is developed in the Washington Office for the Regions in the form of annual budget instructions. The instructions establish alternative funding levels and identify acres and structures of wildlife

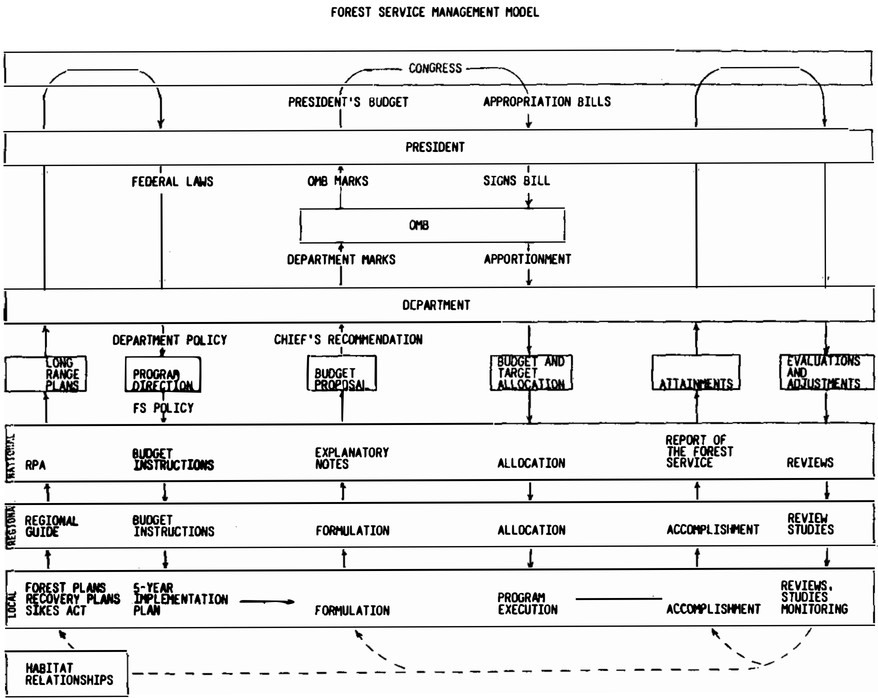

Figure 1. The Forest Service management model is a diagram showing the path through which information flows within the agency, administration, and the Congress required to plan, fund, accomplish, and account for program goals.

habitat improvement each Region is expected to accomplish. The work to achieve the RPA elk goal in the example cited is included in at least one required funding level. The Regions, in turn, request alternative budget proposals from the Forests based on these instructions.

Budget Proposal. Forest personnel, based upon the work described in Forest Plans, formulate their budget proposals to meet the goals for each funding level, as required in the instructions. In most cases, funding levels vary from the full RPA level, which will meet the 18 percent elk goal, to a reduced level deemed necessary to maintain minimal stewaradship, which may result in a decrease in elk habitat capability. The proposal includes the amount of habitat improvement (acres and structures), funding, and workforce requirements needed to meet the Forest's share of the elk goal required by the budget level during that year. At this point, economics are considered in order to select the most cost effective methods and locations to meet the goal with the least funds. Forest budget proposals are combined at the Region into alternatives and submitted to the Washington Office. The particular amount of work or portion thereof to meet the elk goal is still included in the aggregation, but can no longer be identified. The Washington Office formulates national alternatives using a goal optimization model.

It is important to note that, at this point, the agency budget proposal format changes from a multiple-use budget to a program line item in the Congressional budget. Decisions are made on a single program basis rather than from an integrated program objective which may or may not, for example, consider relationships between wildlife and timber.

After the Department approves a budget proposal, it is reviewed by the Office of Management and Budget (OMB). When it is approved by OMB, the proposal becomes a part of the President's Budget and is given to Congress. The work and funding to meet elk habitat capability goals are still buried within the Wildlife and Fish Budget Line Item.

Budget and Target Allocation. Once a budget is approved by Congress and signed by the President, the Washington Office allocates both the work and dollars to the Regions. The budget information is converted from the Congressional line item format back into a multiple-use program. The work to accomplish the elk goal is still unidentifiable and may or may not be included, depending upon the budget level funded for each line item. If the funding level has been reduced, the elk work could be partially or entirely eliminated at the Region or Forest level, based upon priorities.

The Forests develop programs based upon the funding level received by the submissions nearly 2 years previous, and any additional program direction. If the funding is high enough to complete the elk habitat improvement, it will be accomplished. If the Forest Supervisor receives less funds than requested and does not have specific direction about the elk management, he can select a local priority as long as it is within the Forest Plan framework.

Attainment. When the project that is designed to meet the elk habitat capability goal is implemented, the acres and structures of habitat improvement that are completed are recorded in detail in the Annual Wildlife and Fisheries Report and generally in the Management Attainment Report.

The information in the Annual Wildlife and Fisheries Report and the Management Attainment Report is aggregated at the Regional level and forwarded to the Washington Office. Progress toward the RPA goals for elk habitat capability may be estimated, but the acres or structures completed to meet the goal are not identifiable. All forest activities, including wildlife, timber and range management, are considered in making the habitat capability trend estimate. Alternatives are being examined to provide the ability to aggregate both inputs and outputs, by species, for the next RPA period starting in 1990. The estimates of progress toward meeting RPA habitat capability goals will appear in the 1983 Annual Wildlife and Fisheries Report and be species specific. The costs, however, will be major categories (fish, wildlife, threatened and endangered, anadromous fish). This still a major step ahead of the dilemma with acre equivalents. When the Wildlife Management Institute made their review, the Forest Service had no systematic way of determining if goals for increasing habitat capability were being met.

Evaluation and Adjustments. Periodic reviews are made by Washington Office, Regional Office, and Forest personnel to determine how effectively goals are being met. More importantly, these reviews examine quality and cost effectiveness. The management process is continually refined to provide a method of developing and revising policy toward a better program.

Summary

The Forest Service has implemented a goal-oriented approach to fish and wildlife habitat management on the 191-million acres (77.3-million ha) in the National Forest System. Habitat improvements to meet specific goals for management indicator species are quantified and aggregated from the Forests through all Forest Service Administrative levels. The process allows an assessment of the program's ability to meet goals at any funding level proposed and to report accomplishments upon implementation of any funding level.

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Recreation Impacts: A Synthesis of Ecological and Social Research

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Numerous authors have noted the impacts resulting from the burgeoning numbers of visitors to the nation's parks and forests. This paper presents selected findings from a study designed to: (1) synthesize existing theoretical and empirical work related to recreational impacts on a more comprehensive scale than previously attempted, and (2) develop a methodology for carrying capacity estimation which can be utilized in managing the National Parks[1] Only the first objective is considered in this paper. Studies related to two general categories of recreation impacts—ecological and social—are reviewed here. Space limitations have necessitated presenting abbreviated versions of the summary findings.

Ecological Impacts

Research on the ecological impacts of outdoor recreation has focused on the identification of relationships between recreational use and various components of natural resources. Studies suggest that recreational use most strongly affects soil erosion and compaction, vegetative loss and replacement by non-native species, and wildlife behavior and population levels (Stankey 1980). Previous bibliographies and summary articles indicate that the impacts on soil and vegetation are best known, while impacts on wildlife are least understood (Speight 1973, Stankey and Lime 1973).

Vegetation and Soil Impacts

Recreational use of natural areas affects soils and vegetation in a variety of ways. The most typical vegetation impacts include direct reduction in plant growth and ground cover; decrease in the density of herbs, shrubs, and tree seedlings; and changes in species composition and diversity (Tivy 1972). Associated soil changes that can contribute to a decline in plant vigor include the increase in soil compaction, a reduction in organic matter, a decrease in infiltration rates, and an increase in runoff and erosion (Cole and Schreiner 1981, Tivy 1972). Vegetation and soil impacts are complex and interrelated, as evidenced by the variety of indicators that have been examined (Verburg 1977).

Available evidence indicates that the relationship between use intensities and vegetative cover is curvilinear, with even low use resulting in a substantial loss in the original vegetation (Frissell and Duncan 1965, Merriam and Smith 1974, Cole 1982). A major shift in vegetative composition typically follows the initial loss in cover. Delicate and fragile species are replaced by more resistant species (Verburg 1977). Several authors indicate that the extent of impact is more closely related to inadequate trail design, location, and maintenance than to overuse (Helgath 1975,

[1]Support for this research was provided by the National Parks and Conservation Association.

Bratton et al. 1977). Bratton et al. (1977) further suggest that the *intensity* of damage is primarily a function of site factors and type of use, while the *area* of damage is a function of number of users.

Responses of plants to recreational use appear to be strongly associated with the morphological characteristics of plants. These attributes may be expressed either as growth forms, or in terms of the life form concept. Growth forms include descriptions of such features as position in community stratification, type of branching, periodicity and leaf type (Schreiner, pers. comm., 1983). The theory supporting the life form concept suggests that the position of the perennating buds relative to the soil surface governs the survival rates of plants in stressed, impacted environments (Liddle and Greig-Smith 1975).

Species which appear to be most resistant to impact in forested systems combine the characteristics of being woody, prostrate in growth habit, have an underground perennating organ, regenerate by layering, possess sclerophyllous leaves, and have the ability to grow in dry, droughty, or stressed environments where competition is reduced (del Moral 1979). Highly sensitive plants have soft, delicate leaves, a single exposed perennating organ, are active most of the use season, and adapted to wet or moist habitats where soils are easily compacted and competition severe (del Moral 1979). As a subclass of herbs, graminoid species have been found to be much more resistant to impact than other growth forms (Cole 1979).

Morphological resistance appears to be dependent upon site or habitat condition, since soil moisture greatly increases the susceptibility of ecosystem damage to trampling. Plants inhabiting sites having high soil moisture levels such as is found in snow beds, wetlands, and marshes are easily damaged by minimal use. In contrast, it has been shown that growth form plays an important role in mediating the degree of damage on drier sites (Willard and Marr 1970).

Several investigations have ranked habitat classifications according to their relative resistance to impacts (Liddle 1975a, Weaver et al. 1979). Using the number of foot passes required to reduce the original cover by 50 percent as a standard for comparison, Liddle reported a range of 44 to 1,828 and Weaver et al., a range of 25 to 1,100 for several different plant habitats. Based on these findings, Liddle (1975a) proposed that the tolerance of plant communities to wear is strongly related to primary productivity and that this relationship may be used to predict vulnerability. Kellomaki and Saastamoinen (1975), however, found that plants growing under a deciduous forest on sites having either low or high fertility are more susceptible to damage than those found on sites of moderate fertility.

Other studies have reported a positive linear correlation between bulk density of surface soils and increasing levels of use. As use increases, bulk density increases up to a point beyond which further compression does not occur (Wall and Wright 1977). Other findings indicate that as bulk density and soil penetration resistance increase, so do the incidence and percentage of resistant species to total plant biomass (Liddle 1975b).

Dense soils restrict both the rate and extent of root elongation. The effects have been shown to be related to both aeration and soil strength resistance to penetration (Marshall and Holmes 1979). Thus, changes in soil properties reflected by bulk density appear to select for species with greater tolerance to moisture and oxygen stresses, as well as those morphologically adapted to highly compressed soils.

Despite the progress that has been made in understanding plant and soil impacts, only a few factors have been suggested to explain the rapid decline in vegetative cover. For example, it has been shown that nitrifying bacteria decrease and denitrifying bacteria increase in soils that are compacted (Chapell et al. 1971). This displacement in the soil bacterial community implies oxygen stress as well as a change in the form of nitrogen available to plants. Speight (1973) suggests that bacterial populations in woodland soils and carbon-nitrogen ratios may decrease significantly under trampling stress. Populations of important soil fauna which serve to mix and maintain soil friability are reduced because of a decline in organic litter and air spaces in the soil. Moreover, microclimatic changes occur which alter the temperature regimes of impacted areas. These data suggest that soil organisms are affected by lower trampling intensities than those required to produce changes in structure and species frequencies in the plant cover (Duffy 1975).

Wildlife Impacts

Although a recent annotated bibliography included over 200 citations related to human-wildlife interaction (Ream 1980), information on the effects of recreation on wildlife is still incomplete. Findings are often mixed and animal responses to human intruders are divergent, even within a single species (Ream 1980).

Impacts of recreation on wildlife can be a direct result of harassment of animals or can occur indirectly through loss of habitat, food supply, or productivity. Direct wildlife harassment, as defined by Ream (1979: 153) includes "events which cause excitement and/or stress, disturbance of essential activities, severe exertion, displacement and sometimes death." Harassment can be either intentional or unintentional. Several authors suggest that the major impact results from recreationists in "nonconsumptive" activities who unknowingly produce stressful situations for wildlife (Wilkes 1977, Ream 1979). Other writers add that the presence of pets (e.g., dogs) in backcountry recreation areas is a serious form of wildlife harassment, with especially severe effects in winter when wildlife's energy resources are already heavily stressed (Waterman and Waterman 1977, Williams 1978).

Studies examining the indirect influence of human activity on wildlife behavior and population levels document a loss of habitat as a response to human interference. Research on large mammals has found that movement and feeding patterns can be modified by park traffic and roads (Tracy 1977) or by the presence of backcountry recreationists (Faro and Eide 1974). In some cases, these modifications become permanent displacement of habitat. For example, human encroachment on bighorn sheep habitat has forced sheep into smaller areas and poorer, more remote ranges (Hansen 1971, Light 1971). Lieb and Mossman (1966) found that elk moved from primary to secondary forage areas and cows with young moved from the central part of their home range. Such habitat displacement leads to additional stresses on wildlife populations. In one study, deer displaced to poor habitat became nocturnal, experienced reduced reproductive rates and lower fat deposition, and did not return to good habitat after human disturbance (Batcheler 1968). In Colorado, bighorn sheep forced into higher elevation lambing ranges were subject to weather conditions which can cause 80 percent incidence of pneumonia and a resultant decline in population (Woodward et al. 1974).

Previous studies also have documented habitat losses for smaller wildlife found near campsites and trails (Stebbins 1974, Mahoney 1976, Garton et al. 1977a, 1977b). Ream (1979: 162) suggests that "big game species tend to be more affected by direct interaction, whereas rodents, birds, amphibians, reptiles and insects are affected more by indirect impacts such as the modification of the structure of the vegetation."

Human disturbance has been shown in some investigations to result in reduced productivity rates. Research on birds suggests that disturbing nests causes adults to fly off, leaving eggs vulnerable to predation or hatch failure (Hunt 1972, Bart 1977). For young birds, disturbance can lead to premature flight and increased injury and predation (Garber 1972). Such effects have been observed for a variety of species of birds. For those species that have been studied more, such as osprey and eagles, findings have been mixed, with some studies suggesting that nest disturbance had no effect on reproductive success (Ames and Mersereau 1964, Mathisen 1968).

Research has generally found mixed results regarding the relationship between recreation use levels and wildlife population variables. In some instances, populations have declined, while increases have been noted for certain species in other situations. In a desert environment, Sheridan (1978) found that moderate use led to a 60 percent loss of animal life while heavy use resulted in a 75 percent loss. Mahoney (1976) reported that increasing campground use was associated with a loss in insect density and species diversity. Elgmork (1978) observed that bear density was lower in areas with greater development of roads and holiday cabins. In Yellowstone National Park, Chester (1976) found an inverse relationship between intensity of human use and frequency of wildlife observations.

Other studies, however, report a positive relationship between use levels and wildlife populations. The abnormally high populations of certain species in impacted environments are generally attributed to an increase in food supply from recreational visitors, and have been documented for small mammals (Carothers and Aitchison 1976, Clevenger and Workman 1977, Garton et al. 1977a), birds (Garton et al. 1977b) and bears (Steinhart 1978).

Research has identified a variety of factors that influence both the frequency of human-wildlife encounters and the response or vulnerability of wildlife to the encounters. These factors include the wildlife species and its feeding and breeding characteristics; the type, degree, and length of disturbance; and season and weather conditions (Wall and Wright 1977). Ream (1979: 153) notes that "well-fed, healthy animals with ample refuges from disturbance can withstand more harassment than wildlife already under stress from severe weather, malnutrition, parasite loads, birth or nesting, or inadequate security areas."

Animal characteristics and group sizes also influence the outcome of human-wildlife encounters. Females with young generally seem to be affected most (Tracy 1977, deVos 1960, Light 1971). Stalmaster and Newman (1978) report evidence, however, suggesting that older birds are more sensitive to disturbance than younger birds. Sheep were more susceptible when in smaller groups (Hicks 1977) and caribou similarly showed variation in flight distance with band size (deVos 1960).

Some types of recreational activity have greater effects than other types. Studies of ungulates (Tracy 1977, Ward 1977) and shore birds (Blodget 1978) indicate that out-of-vehicle activity can be more disturbing than vehicular traffic. Visitor party size, behavior and noise levels can influence the frequency and outcome of wildlife encounters (Chester 1976, Tracy 1977, Whittaker 1977, Singer and Bratton 1976).

Similarly, the location of the encounter plays an important role. Chester (1976) found that bear contacts were greater at lower elevation and were three to four times more likely off the trail than on the trail. Hicks (1977) observed that sheep were more disturbed by humans approaching from above rather than below. Eagles appear to be more affected by disturbances on nearby water or gravel bars than on land (Stalmaster and Newman 1978). The amount of browse and escape cover at the location of interaction also appear to be important variables (Clevenger and Workman 1977, Telfer 1978).

Overall, the available empirical evidence highlights the complexity involved in understanding recreational impacts on both the physical environment and specific wildlife populations. Relatively low numbers of visitors can seriously disrupt the amount of vegetative cover in given areas and result in erosion problems. Among certain species of wildlife, encounters with even a few humans can alter behavior patterns and influence reproductive and survival rates. These findings stress the importance of recognizing the inherent differences between species and resource characteristics when evaluating the impacts associated with recreational use.

Social Impacts

Research related to use impacts has also examined the effects of increasing visitor numbers on the quality of the recreation experience. Most existing studies have examined factors related to either visitor satisfaction or perceptions of crowding to determine the social impacts of varying levels of use density.

Visitor Satisfaction

The concept of satisfaction is central to most discussions of social impacts. Researchers and managers have consistently argued the "goal of recreation management is to maximize user satisfaction" (Lucas and Stankey 1974:1).

Several papers (Alldredge 1972, Fisher and Krutilla 1972, Cicchetti and Smith 1973) have presented theoretical models for determining social impacts. This research indicates that satisfaction declines as use levels increase. These studies, however, investigated the effects of "hypothetical density" on users' perceptions of the experience. More recent investigations which examined the bivariate correlation between actual density and satisfaction have failed to confirm the predicted inverse relationship (Heberlein and Vaske 1977, Manning and Ciali 1980, Shelby 1980). Recreationists generally report high levels of satisfaction regardless of the density levels they encounter. Nor does the level of satisfaction appear to vary with individual characteristics, places or activities (Ditton et al. 1981).

Plausible explanations for this situation have been suggested by several investigators. One school of thought suggests that it is not surprising to find many people reporting high satisfaction with their leisure activities because they have freely chosen these activities to provide satisfaction. Heberlein and Shelby (1977) suggest that because recreation activities are self-selected, individuals who are sensitive to increasing use levels are likely to be displaced to other resources. Those who remain will either be more tolerant of higher densities or will have adjusted their expectations to compensate for the situation. Schreyer (1979) elaborates on the psychological mechanisms that may yield reports of high satisfaction: (1) individuals may *shift their perceptions* of the experience away from original evaluations in order to maintain the desired experience, (2) individuals may *shift their priorities* of expectations to maintain satisfaction, or (3) individuals may *change their behavior* to achieve preferred outcomes that have not been attained during previous occasions.

All of these potential explanations rely on a multiple satisfaction approach to defining the recreation experience (Hendee 1974). This conception of satisfaction revolves around discrepancy theory and converges on the following explanation. Participants engage in recreation activities with the expectation of certain rewards (Driver and Tocher 1970). Most people engage in recreation to satisfy multiple expectations (Schreyer and Roggenbuck 1978). In evaluating the experience, they compare the outcomes they received with the rewards they expected or wanted to receive. Overall satisfaction in any situation results from the discrepancies that exist for each expected reward (Peterson 1974). Thus, it is unrealistic to expect satisfaction to be determined by a single situational variable like use intensity.

Perceived Crowding

A number of authors have made the important distinction between density and crowding (Stokols 1972, Altman 1975). Density refers to the number of individuals in a particular setting. Crowding is the negative evaluation of a certain density; a value judgment which specifies that there are too many people. This means that whether an area is crowded or not is a subjective judgment of an individual, not an objective fact. Consequently, it will vary across individuals depending on a variety of social and psychological factors.

The traditional model suggests that use levels influence the number of contacts between people and contacts influence perceived crowding. Our research identified 13 studies that present data on the relationships between "actual density" and perceived crowding. Ten of these investigations reported a positive and significant effect. As use levels increased, recreationists were more likely to evaluate the experience as crowded. The magnitude of the observed correlations ranged from 0.01 to 0.61, with an overall average of only 0.22. This suggests that the relationship between actual density and perceived crowding may be attenuated by the individuals' perceptions of the experience. Research related to the effects of perceived contacts, rather than actual density, on feeling crowded reveals stronger and more consistent levels of association. Twelve of the studies identified indicated positive relationships, with an average correlation of 0.40.

Researchers have also begun to investigate other potential factors that may influence perceptions of crowding. Several studies (Schreyer and Roggenbuck 1978, Bultena et al. 1981, Absher and Lee 1981, Ditton et al. 1983, Shelby et al. 1983) show that expectations and preferences for encounters influence perceived crowding. Recreationists feel more crowded when encounters exceed expectations and preferences. Some investigations suggest that perceptions of crowding are interrelated with perceptions of environmental quality. Bultena et al. (1981) and Vaske et al. (1982) found a positive correlation between human-use impacts of previous visitors and perceived crowding. Visitors who evaluated the natural environment as more disturbed tended to report higher levels of crowding. Other researchers (Stankey 1973, Lee 1975) indicate that people were more disturbed by the presence of litter or other environmental damage than they were seeing people.

Consistent with these observations, some studies show that where encounters occur, group size, method of travel and the behavior of other individuals have a more significant impact on recreationists' experiences than the total number of visitors. Contacts at the campsite were perceived more negatively than encounters along the trail (Stankey 1980). Encounters with a large group had more impact than seeing smaller parties (Stankey 1973). Paddling canoeists (Lucas 1964), hikers (Lucas 1971) and crosscountry skiers (Knopp and Tyger 1973) were more disturbed by contacts with motorized canoeists, trailbikers, and snowmobilers, respectively, than they were with other nonmotorized users. Lee (1975) found that the demeanor and friendliness of the group encountered influenced respondents' evaluations of the quality of their experience.

Finally, some studies have introduced the notion of contact preference norms as an approach for better understanding visitors' crowding tolerances. The unique aspect of this approach is that people are asked directly how many contacts are acceptable for a given type of experience (Lucas 1964). Shelby and Heberlein (in press) have identified separate contact norms for different types of experiences (e.g., wilderness, semi-wilderness, and undeveloped recreation). Results of these studies show that contact norms vary for different types of recreation experiences and among individuals within a given activity.

Overall, research related to social impacts has apparently followed a developmental sequence in which the explanation became more complete as the concepts and required measures became more specific. Although empirical studies have failed to substantiate the original premise that satisfaction should decrease as the number of users increases, impacts in the form of shifting expectations or visitor displacement have occurred. Subsequent research focusing on the perception of crowding found greater variation in the response measures and more consistent empirical relationships with use levels, suggesting that perceived crowding and contact norms are useful indicators of social impacts.

Synthesis and Conclusions

It is apparent that both the integrity of natural resources and the quality of the visitor experience are influenced by increasing recreational use. Our examination of the existing research suggests some similarities and some differences between the ecological and social impact literature.

The available evidence from either area of emphasis notes that the impacts of recreation take a variety of direct and indirect forms. Many factors influence the incidence and severity of impacts. For example, the type and location of use may have more important consequences than number of users upon natural ecosystems and visitor experiences. Wide variability in the response to human intrusion seems to be another common denominator between social and ecological research. In ecological terms this variability is most evident as differences between types of environment or individual species. In social research there is much diversity among user groups and individuals in their response to other visitors. Finally, in spite of the research that has been completed, much remains unknown about both the ecological and social consequences of outdoor recreation.

Differences between the ecological and social literature seem to center around different research procedures and associated difficulties and limitations. Ecological impacts occur within ecosystems characterized by complex interactions between many plant and animal species. Wall and Wright (1977) suggest four factors that limit ecological studies and introduce difficulties in identifying human impacts: (1) there is often no baseline data for comparison to natural conditions; (2) it is difficult to disentangle the roles of man and nature; (3) there are spatial and temporal discontinuities between cause and effect; and (4) in light of complex ecosystem interactions, it is difficult to isolate individual components. Some impacts take the form of naturally occurring processes that have been speeded up by human interference (Wall and Wright 1977). In other cases, human disturbances become insignificant when compared to natural fluctuations and disturbances (Schreyer 1976).

Impacts on wildlife are perhaps most difficult to identify. Many studies and individual accounts describe avoidance behavior by animals, but less research has focused on the actual effects of this behavior. Very little attention has been given to the relationships between *numbers* of park visitors and wildlife behavior and population variables. The literature on wildlife has tended to identify general types of impacts resulting from recreation land development, pollution and other broad categories of human activity.

Research on social impacts avoids the problem of multiple species and concentrates on only the human response to other visitors. As a result, many studies can be identified which deal specifically with relationships between use levels and visitor experience parameters. The understanding of social impacts, however, remains incomplete because of the complexity of human values and behavior. In addition, some types of social impacts are difficult to evaluate due to logistical constraints. For example, displaced visitors who no longer use a given area cannot be located easily. Psychological adjustments visitors make when confronted with too many people require elaborate procedures that are usually beyond the time and budget constraints of most field studies.

Attempts to reduce recreation impacts or to apply this understanding to management generally introduce the notion of carrying capacity and use level restrictions. While it is beyond the scope of this paper to summarize current views on carrying capacity application, it seems appropriate to conclude with some reference to the use of visitor impact data for park and natural resource management. Since even low use levels can produce significant impacts, most authors agree that visitor capacity decisions ultimately depend on value judgments that specify how much impact is acceptable in a given situation. Such judgments, however, can be aided by knowledge of the relationships between use and ecological/social changes (Stankey 1980). "Research will not explicitly determine recreation use limits, but will indicate to planners and managers the range of the capabilities of the environment for recreation" (Wall and Wright 1977: 51).

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Michigan's Land Leasing Program for Public Hunting

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Introduction

Before discussing the Michigan program and its implications, I would like to acquaint you with our state and some of the factors which stimulated interest in this program. Approximately 90 percent of Michigan residents reside in the lower one-third of the State, which contains only about 3 percent of our publicly owned land. Rising land prices and land management costs coupled with declining revenues have seriously eroded Michigan's ability to acquire and effectively manage public lands. Even if our economy improves substantially, it is unlikely that our public agencies will recieve the financial resources or political support required to adequately address Michigan's public land distribution problems.

Several trends are emerging in Michigan that exacerbate an already difficult situation. Rising travel costs have effectively curtailed the distance that many southern Michigan hunters can afford to travel. The amount of open space in this region is being reduced by conversion to other uses and much of that which remains is being posted. However, our studies reveal that most landowners remain willing to grant access to at least some hunters and other recreationists, mainly family and friends, while only a shrinking minority are still willing to grant access to almost anyone who requests it.

The problem facing southern Michigan hunters, especially those residing in urban areas, is finding those few landowners still willing to grant access to their properties. The total costs of searching for a place to hunt, both in terms of time and travel, are immense considering the tens of thousands of hunters involved.

The Michigan program, known locally as the Public Access Stamp Program (PAS), is to some degree reducing the hunting access problem. In the following section, the structure of the Michigan program will be discussed along with how it has been perceived by: (1) hunters, (2) landowners, and (3) the agency that administers it. In the final section, the focus will be on what has been learned in Michigan and how it might be employed to reduce open space access problems in other regions and for other forms of recreation.

The Michigan Public Access Stamp Program

How it Originated

The PAS Program was initiated in the fall of 1977. It was created by an Act of the Michigan Legislature. Act No. 373, Public Acts of 1976, states that the Michigan Department of Natural Resources" . . . shall lease private lands to provide public access for the purpose of hunting." Funding for the program is derived from the sale of $1.00 public access stamps, required of all who hunt in southern Michigan.

The spark which ignited interest in the program was the cancellation of a similar program, the "Pilot Public Access Program," by the U.S. Agricultural Stabilization and Conservation Service (ASCS). The ASCS program involved five southern Michigan counties and a similar number of counties in nine other states. Analysis of the ASCS program indicated that it was popular among both hunters and landowners but failed to open significant acreage previously closed to hunting (Womach et al. 1975). It was effective, however, in helping hunters to locate landowners willing to permit hunting.

Michigan United Conservation Clubs first suggested the PAS Program and quickly received support from our Farm Bureau. The Michigan Department of Natural Resources was not particularly active in initiating or lobbying for the program. In fact, the Wildlife Division, which was assigned administrative responsibility for administering the program, was surprised by the quick passage of the enabling legislation.

How it Works

The program covers all or portions of 41 of Michigan's southernmost counties, roughly the southern one-third of the State. The existence of the program is publicized in various ways to recruit landowners. Agency personnel appraise all properties offered for lease. If found acceptable for hunting purposes, a lease agreement is signed, and the owner receives signs to delineate the property and tags to issue to hunters. These tags substitute for the written permission document required to hunt on private lands, and the number of tags the landowner receives is based on the number of hunters the property can safely accommodate. Leases are negotiated for a three-year period, but payments are made at the end of each hunting season. A variable payment structure is used to determine the total payment to the landowner. Initially, the structure ranged from $2.50 per acre ($6.17 ha) for prime habitat (marsh, idle fields, brush, etc.) to $0.50 per acre ($1.24 per ha) for less prime habitat (grazed pasture, etc.). Later, the payment structure was adjusted upward for urban regions where recruiting landowners was found to be more difficult.

Hunters learn about the program in several ways; many only when forced to purchase the required Public Access Stamp. Initially, they were required to contact the agency for a landowner listing, but now these are distributed by license dealers as well as agency offices. The hunter must contact the landowner and be issued a tag before entering the property to hunt. He is expected to confine his activities to areas designated by the landowner and to return the tag upon completing hunting.

The administering agency is essentially a liaison between hunters in need of a place to hunt and landowners willing to grant them access. The agency recruits landowners, determines the payment they will receive, and provides them with signs. It informs hunters of the program, provides them with information on available properties, and collects a $1.00 fee to offset program costs.

With a general understanding of the program and how it is supposed to function, we can now turn to examining how the program is working from several different perspectives. Initially, the most noteworthy problems with the program were the absence of a plan to implement it and the void of information needed to develop such a plan. The Wildlife Division found itself with a program it had not requested and which it was poorly prepared to implement. The second significant problem was the relatively short lead time the Division had to implement this major new program.

These more general problems spawned many others that had to be resolved. For example, neither license dealers nor hunters were well aware of the program. Thus, stamp sales were and continue to be less than expected. The approach to recruiting landowners was so "low key" in the first year that total acreage leased was far less than desired, and much of it was of marginal hunting quality. Unfortunately, very little land was leased in Michigan's most populous counties where access is most difficult. Furthermore, program properties were unevenly distributed across the region. Hunters complained of the "hassle" involved in obtaining information about the program and the lack of information provided concerning the properties' locations and the nature of their game habitat. Many landowners failed to post the signs provided or weren't home to issue tags to hunters. There is little doubt that the program would have been considered a failure based upon its first year's performance, but the Wildlife Division had the time to identify problems and to make adjustments since the program was established to run through December 31, 1982. The improvements made since that first year can be attributed to the sincere interest of program administrators in making the program work and careful monitoring of the program, including investing in research to fill in information gaps.

The Administering Agency's Perspective on the Program

John Urbain, who currently directs the program for the Wildlife Division, has collected some statistics which shed considerable light on the history and progress of Michigan's PAS Program. Some of these are summarized in Table 1. Note that both the number of farms and total acreage leased have nearly doubled since the

Table 1. The Michigan Public Access Program: Trends in key statistics. (Source: Wildlife Division, Michigan Department of Natural Resources)

Season[a]	Farms leased	Acres leased	Acres leased in urban counties[b]	Average payment per acre	Total Costs	Total Revenues
1977–78	473	93,513 (37,860 ha)	32,066 (12,982 ha)	$1.25	$165,000	$448,000
1978–79	535	105,958 (42,898 ha)	32,200 (13,036 ha)	$1.22	$225,000	$372,000
1979–80	559	119,778 (48,493 ha)	25,171 (10,191 ha)	$1.29	$269,000	$354,000
1980–81	686	160,228 (64,870 ha)	54,154 (21,925 ha)	$2.07	$422,000	$343,000
1981–82	792	188,691 (76,393 ha)	67,946 (27,509 ha)	$2.17	$500,000	$320,000

[a]The hunting season in the Program region includes the period September 15—March 1.
[b]Urban counties are those in the Program region with the densest population distribution.

program's first year. Acreage under lease in urban counties has more than doubled, and although not obvious from the data in Table 1, overall distribution of leased acreage is much improved. The last two columns of Table 1 indicate that the surplus generated in the program's early years has almost disappeared. If the program is to remain self-supporting, it is becoming obvious that some action will be necessary to augment revenues or cut program costs.

Cost reductions could be generated by reducing total payments to landowners, either by reducing total acreage leased or average per acre payment. Neither is especially attractive because the former would likely produce crowding on lands remaining in the program which would create dissatisfaction among both landowners and hunters. Per acre fee reductions isn't an attractive option either because leasing higher quality habitat, especially in urban counties, would become more difficult. Program revenues might be increased by either increasing the cost of the stamp or by insuring that a greater percentage of hunters purchase it as required. While a fee increase would not be unreasonable, given its minimal level now and the program's proven effectiveness, the administering agency plans to focus on increasing compliance in the coming year. It believes that the decline in revenue resulted from confusion surrounding recent adoption of a new licensing system, the pass book system, and revision of laws to implement this system. Now that license dealers, hunters and law enforcement personnel have adjusted to these changes, stamp sales are expected to increase considerably. Also, license dealers will begin earning a fee for each stamp sold, which is expected to further stimulate stamp sales.

In 1977–78, the program's first year, about 23,000 hunters participated in the program, hunting an estimated 35,000 days. By the 1980–81 season, 75,000 hunters hunted 890,000 days on PAS properties. In the 1980–81 season, public areas accommodated approximately 28 percent of the total hunter days registered in southern Michigan; the PAS program supplied about 12 percent. Each acre of public hunting land in this region provided 6.0 days of hunting; PAS program lands supplied 5.6. Cost per hunter day provided on PAS lands was \$0.47, while in lieu of property tax payments on public hunting areas alone was \$0.66 per hunter day. If one were to include the other costs attributable to managing these public areas, the cost per hunter day provided on public areas would increase dramatically. Thus, Michigan's PAS Program compares favorably with the alternative of providing more public hunting areas. PAS properties serve about the same number of hunters per acre per year at a relatively low cost per hunter day. It is interesting to note that, for a similar program in New York, cost per hunter day was estimated to be \$9.96 (Brown and Dawson 1977).

Landowners' Perspectives on the Program

All landowners who enrolled in the program at the beginning of the program's second season (1978–79) were surveyed (Feltus 1979). Approximately 95 percent responded, including about ten percent who had dropped out of the program or who planned not to renew their leases. About 75 percent of these landowners reported that they had permitted hunting on their properties prior to enrolling in the PAS program. Thus, the program was not especially effective in opening lands previously closed to hunting. Responding landowners were overwhelmingly positive about the program as evidenced by the finding that about 96 percent of those remaining in the program at the season's end planned to renew their leases for the following year. Fifty percent of the respondents indicated that the payment they received was the primary reason for enrolling in the program and for continuing to participate. About 50 percent of those who stopped participating indicated they did so because the payment received was inadequate. About one-third of the respondents reported improved relations with hunters, while only 4 percent reported worsening of relations with hunters.

Respondents offered several suggestions for improving the program. Most (78 percent) felt the State should offer them free legal services; 75 percent suggested that the payment they received should be increased. About 70 percent suggested that the program would be enhanced if compensation for property damages was provided by the State. Finally, about 15 percent reported they had received some negative comment from one or more neighbors concerning this program. The latter finding prompted us to investigate the nature and extent of negative spillovers from the PAS Program onto adjacent lands.

Questionnaires were mailed to owners of a random sample of properties immediately adjacent to those enrolled in the PAS Program. Over 40 percent of those responding indicated they weren't aware that a neighbor's property was enrolled in the program. About 20 percent, however, indicated that they had been negatively impacted in some way by hunters participating in the program. The most common problem reported was increased trespassing. On a more positive note, about one-third of this group of landowners indicated an interest in enrolling their property in the program. Thus, improved delineation of PAS Program boundaries and reduction in the number of hunters violating them would essentially eliminate the negative spillovers from the PAS Program.

A third survey was developed to assess how landowners not involved in PAS perceive this type of program, both for hunting and for other selected outdoor recreation activities. Roughly equal numbers of properties were selected in the four most populous Michigan counties (i.e. Wayne, Oakland, Macomb and Washtenaw) and from among the remaining counties in the southern one-third of the State. For convenience, the latter will be referred to as rural landowners and the former urban landowners. Fewer urban landowners (42 percent) allowed hunting on their properties than their rural counterparts (69 percent), and only 14 percent of urban landowners were willing to grant this privilege to "anyone who asks," as compared to 30 percent for rural landowners. Hunting is allowed on only 33 percent of properties within five miles (8 km) of a major city, but is permitted on 75 percent of properties beyond 50 miles (80 km) of a major city. More landowners indicated willingness to permit cross-country skiing (84 percent) and hiking (72 percent) than hunting (54 percent), snowmobiling (37 percent) and motor biking (12 percent).

Overall, about 5 percent of all responding landowners indicated that they would be willing to participate in a PAS type program, a somewhat surprising result since more than 20 percent indicated that they now allow almost everyone who asks to hunt. This inconsistency appears to be linked to landowners wanting to retain the right to refuse access when they so desire and a general lack of confidence in government programs.

The following three general conclusions can be drawn from these findings:

1. It will be more difficult to recruit "urban" than "rural" landowners to participate in a PAS type program.
2. It will be far easier to recruit landowners to participate in PAS type programs for some recreation activities than for others. This conclusion is also supported by a previous Michigan study (Holecek and Westfall 1977).
3. PAS type programs need to be actively "marketed" because only a relatively small percentage of landowners are currently receptive to them.

Hunters' Perspectives on the Program

Hunters were systematically queried concerning the program following both the first and fourth years of the program. Thus, both their initial reactions to the new program and their later reactions to a much more refined program are available. In the first year of this program, about 23,000 hunters hunted a total of 35,000 days on leased lands. By the fourth year, the number of hunters served increased to 73,000 and days hunted to 890,000. Interestingly, less than 75 percent of hunters surveyed after the first season were aware of the program even though almost all should have purchased a Public Access Stamp (Westfall 1980). Of the hunters aware of the program in its first year, only 25 percent attempted to find out more about it; only 10 percent obtained a listing of properties enrolled in the program; and only 6 percent actually hunted on PAS enrolled properties. Thus, slightly less than five percent of southern Michigan's hunters participated in the program in its first year. In fact, 25 percent of the hunters sampled in that year suggested that the program should be terminated. Most of the remaining respondents weren't happy with one or more aspects of the program and suggested: (1) improving the quality of information available concerning the program; (2) making the information easier to obtain; and (3) leasing more land closer to their homes. By the time hunters were questioned again about the program after its fourth year, the administering agency had responded in a significant way to these three suggestions for improvement. Although approximately the same percentage of hunters queried in both surveys suggested the program should be terminated, three times as many hunters were participating by the program's fourth year, and the number of hunter days supplied on these properties had increased to more than 20 times the first year level. While the program is serving only a minority of Michigan's hunters, it is a significant minority which appears to be growing.

Implications for Other Regions and Other Activities

Land leasing is not a panacea for all recreational land use problems. Our study of the Michigan program and a review of the literature on the subject suggest these programs have a number of advantages and some disadvantages over other available options. These are highlighted below.

Advantages

Land leasing's greatest advantage over most alternatives, especially that of purchasing land in fee simple, is its generally lower cost per recreation day provided. Not only does the agency avoid land purchase costs, but leasing land also offers the additional advantage of the owner bearing the property tax and land management costs. An additional advantage is that leased land continues to provide agricultural and forest products, some of which would be lost were the land to be converted to public ownership. Finally, leasing land for relatively short periods permits a quick response to new open space demands while minimizing the risk of investing scarce resources in areas and facilities which may become obsolete as user demands change.

Disadvantages

The short term nature of a leasing program is both an advantage as noted above and a disadvantage. It can be a disadvantage because the agency has limited control of the leased lands for only a short time, and thus it cannot develop long range plans for them. Few public agencies now employ staff with the orientation or experience to administer a leasing program which can prove to be another disadvantage. However, Michigan was able to implement its program without adding new staff. A final potential disadvantage is that it may bring landowners now providing free access to demand payment for the access privilege. We have no evidence that this has occurred in Michigan, but a New York study suggests that once landowners receive payment for allowing hunting, they expect it to continue (Brown and Dawson 1977).

Recommendations

Basically, Michigan's PAS Program provides a marketing service in that it links those with a product to sell (i.e., private landowners) with potential consumers of the product (i.e., hunters). Thus, an agency charged with administering such a program must insure that the program is oriented to the needs of all groups that the program is designed to serve. Ideally, the agency should develop a fairly comprehensive plan for its program which should highlight the following elements:

1. A set of quantifiable objectives.
2. Strategies for marketing the program to targeted landowners and recreationists.
3. A research and evaluation strategy to develop information needed to refine the program and to assess whether or not it is effectively meeting its objectives. In Michigan, research and evaluation has contributed so much to the PAS Program's success that I would recommend assigning these functions very high priority in the program's budget allocation process.

The plan, while a key ingredient in both organizing to deliver the program and in managing it once underway, will be implemented by people. Thus, well-qualified and committed staff should be assigned to direct the program. Personnel assigned to the program should be encouraged to become involved in all aspects of the program. There is probably no quicker way, particularly early in a program, to determine what is and isn't effective than for program administrators to spend a few days afield in the role of a program participant.

Unless landowners are willing to enroll their properties in this type of program, it will clearly fail. To enroll a substantial acreage will require persistence and a willingness to present landowners with an attractive package of incentives. In the Michigan program, the lease payment has clearly been the key incentive in recruiting landowners. However, the others listed below merit consideration for inclusion in the incentive package offered to landowners:

1. Provide liability insurance or free legal services.
2. Grant the owner the right to limit number of users.
3. Provide priority law enforcement assistance.
4. Provide compensation for any property damages.
5. Offer higher payments for quality land and in counties where open space access is most limited.
6. Avoid access leases covering too wide a range of uses.

Program administrators should also pay special attention to the geographic distribution of the properties enrolled in the program. The goal should be a relatively even distribution of program lands across the region, with concentrations only in counties with greatest need. When possible, leasing several large, contiguous properties is better than leasing smaller, scattered properties. Finally, it is perhaps best not to lease any land in any one county unless enough acreage can be leased to avoid serious crowding.

In conclusion, one should not expect a new program to be immediately successful. Time is required to work out problems that arise. Ideally, the administering agency should have a year to prepare for implementing the program and three to five years thereafter to give it a fair chance to succeed.

Summary

Michigan's private land leasing program for hunting has not opened vast acreages to hunting, nor have most Michigan hunters ever hunted on a leased property. If it had been terminated after its first year, it probably would have been considered a complete failure, but fortunately it wasn't.

Since that first year, total acreage enrolled in the program has nearly doubled; the number of hunters participating has more than tripled; and nearly 900,000 days of hunting occurred on program lands by its fourth year of existence at a cost of less than 50 cents per hunter day. Michigan's PAS Program is now effectively playing a significant marketing role linking hunters in need of a place to hunt to landowners willing to grant them access. It is an option that merits wider consideration in other regions of the country and for other recreational activities.

The program, which was due to terminate on December 31, 1982, has been renewed. The vote for renewal was almost unanimous in both the Michigan House of Representatives and Senate.

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Status of Wild Horse and Burro Management on Public Rangelands

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Introduction

When Congress passed the Wild Free-Roaming Horse and Burro Act of 1971, it gave ownership to an estimated 17,000 horses and 8,000 burros which, unlike indigenous wildlife and domestic livestock, had been claimed by no one. Population increases of these animals since passage of the Act have aroused the concern of livestock people, wildlife interests, and environmental groups. The unusual coalition of these three interest groups stands in political opposition to the horse and burro protection organizations, which, except for the humane groups, are largely invisible or uninvolved in most environmental and natural resources arenas.

The political heat generated over this matter has made it one of the more controversial environmental issues in the western United States. The result has been two Congressional Acts, mention in other proposed or enacted legislation, appointment of a national advisory board, a Congressionally mandated National Academy of Sciences (NAS) study, and a 1979–83 research program funded by the Bureau of Land Management (BLM) and U.S. Forest Service (FS). This paper outlines the history of this unusual issue, reviews key management-related ecological findings from the published literature as well as the NAS and BLM-FS studies, and discusses the current management dilemmas. The emphases and interpretations are my own and have not necessarily been endorsed by the NAS Committee, although most are in accord with its two reports. Interested readers might consult them for the degree of correspondence.

Wild Horse and Burro History in North America

The mainstream of equid evolution occurred in North America. Eurasian and African species originated from closely related forms that spread from North America prior to the Pleistocene extinction of *Equus* on this continent 8,000 to 12,000 years ago. The North American fossil record contains close relatives of every contemporary African and Eurasian species of *Equus*—horses, wild asses, and zebras—except the unique African quagga (Bennett 1980). The Eurasian wild horse *(E. caballus przewalskii)* is thought to be the same species as its fossil North American counterpart.

Horses were reintroduced into North America by the Spaniards in the 16th century. Escapes ultimately populated the continent with Spanish mustangs, variously estimated at 2 to 7 million animals by the 1800s (Ryden 1978, Thomas 1979). Burros came later, the feral animals now occurring in southwestern U.S. generally agreed to be the descendents of work animals that escaped or were released in the 1800s.

As the continent became settled, wild mustangs experienced much the same fate as the native wild ungulates. Many were captured, broken, and bred for saddle animals in the livestock-rearing areas of middle and western North America. Others were simply shot, or rounded up and sold, their competition for forage not being tolerated by a growing livestock industry.

This removal process was apparently accelerated after passage of the Taylor Grazing Act in 1934 (Ryden 1978:209–213) by which time the number of horses had been reduced to an estimated 150,000 (Thomas 1979:42). The act authorized formation of the Grazing Service (subsequently BLM), which was empowered to limit previously uncontrolled grazing on the Public Domain, and gave added impetus to removal of wild equids. Meanwhile, the animals' meat had assumed considerable economic value for pet food, and this further accelerated their capture and removal (Thomas 1979:43). At this point they were claimed by neither the states nor the federal government.

By the 1950s, a small number of concerned westerners were fearing the demise of wild horses and began to take their concerns both to Congress and the general public. In 1959 Congress passed the Wild Horse Annie Bill, so entitled from the nickname of Mrs. Velma Johnston of Reno, who almost single-handedly lobbied for its passage. The law prohibited harassment or hunting of wild horses on the Public Domain with motorized vehicles or aircraft.

In the ensuing two decades, the plight of wild horses and burros became a national cause. Wild-horse protection groups were formed which, along with several humane organizations, aroused the concern of people throughout the country. In the summer of 1979, one day's mail on the subject to BLM's Washington office filled a cardboard box two-feet square and a foot deep.

This pressure was translated into passage of the Wild Free-Roaming Horse and Burro Act of 1971 which declared that

> . . . wild free-roaming horses and burros are living symbols of the historic and pioneer spirit of the West . . . [and] they are to be considered in the area where presently found, as an integral part of the natural systems of the public lands.

The public lands referred to are the national forests and BLM lands. The provisions of the Act, and assignment of wild horses and burros to the national heritage, did not apply to animals residing in national parks, federal wildlife refuges, and military reservations. Agencies responsible for those lands are at liberty to manage, or dispose of, the animals at their discretion.

Wild (or feral) equids on national forests and BLM lands now became a public resource and could not be destroyed or taken legally any more than other natural resources on these lands, except as regulated by the federal government. BLM estimated that there were 17,300 horses and 8,100 burros on the Public Domain prior to the Horse and Burro Act's passage in 1971 (Anon. n.d.). In 1982, most of the horses and burros (94 and 99 percent, respectively) on Public Domain and national forests combined were on the Public Domain (Anon. 1982). If the same approximate distribution prevailed in 1971, and if the 17,300 and 8,100 estimates were anywhere near correct, then these numbers approximate the total numbers of animals on the two classes of public lands combined at that time. I will, however, question the accuracy of these estimates later.

BLM and Forest Service began annual censuses of horses and burros on their lands around 1971. By 1976 they were reporting well over 50,000 horses and 7,000 burros on their combined lands (Anon. 1982). Such statistics, plus the subjective observations of stockmen, wildlife specialists, and environmentalists aroused concern over the increase of wild equids on public grazing lands. Ranges were reported to be depleted in some areas, and stockmen resented the grazing competition with livestock. Wildlife advocates were concerned about competition with native game species for forage, and traditional environmental groups were fearful of the ecological impacts of proliferating exotic animals on western ecosystems.

All of these groups were challenging the notion that the extant wild horses were actually descendents of Spanish mustangs. Instead they claimed that most were the legacy of escaped or released cavalry mounts, draft animals, and saddle horses. Hence they did not, in the view of these people, merit the romantic attention they were receiving.

BLM and Forest Service were not without a procedure for removing animals from the public land and limiting population growth. In 1973 they had begun the Adopt-A-Horse and Adopt-A-Burro programs in which they rounded up animals and invited the public to adopt them and assume their care for an average fee of $65 per animal in 1980 (Anon. 1982). But the per-animal costs of rounding up and adopting them out approached ten times this value. Hence, the magnitude of the program depended largely on the amount of appropriated funds to support it.

The $400,000–$2.7 million appropriated in the early and mid-1970s would not permit removal of enough horses and burros to prevent population increase. But the $4–7 million budgets in 1978–1981 made substantial removals possible, and numbers on BLM lands peaked at an estimated 54,030 horses in 1978 and 12,171 burros in 1980 (Anon. 1982). By September 30, 1981, 29,977 horses and 5,088 burros had been adopted and herd estimates were down to 44,930 and 11,870. Horse protection groups became reconciled to the fact that the weight of political pressure would not countenance continued and indefinite population increase and eventually conceded that the round-ups and adoption program were for the most part humane and well carried out.

But opponents of wild equids considered the populations of the late 70s and 80s excessive and continued to agitate for more forceful action. In a climate of less acute environmental concern than that of the 60s and early 70s, and growing political influence in the western states, Congress passed the Public Rangelands Improvement Act (PRIA) of 1978.

PRIA expressed concern for the condition of the public rangelands and raised the question of possible wild equid implication in this condition. It reiterated what had been called for in the Wild Free-Roaming Horse and Burro Act of 1971: Appointment of a National Academy of Sciences study of the problem and a research program that would provide the knowledge on which to base sound management decisions.

A 12-person Committee on Wild and Free-roaming Horses and Burros (later expanded to 14) was appointed by NAS in 1979 and began a three-phase effort. In Phase I, the Committee conducted an exhaustive review of available information on wild equids, delved into BLM and Forest Service files, interviewed agency personnel, and produced a massive report in late 1980 (Wagner et al. 1980). In addition to reviewing the state of knowledge, the report designed a research program to be funded by BLM and the Forest Service. The research design included some 25–30 individual research projects to be carried out in a number of areas over the West.

Phase II constituted the Committee's oversight of the actual research program. It began on a small scale in 1980 with four competitively bid projects: two contracted to the University of Wyoming, one to Colorado State University, and one to the University of Minnesota. Two more were added in 1981, but by that year fiscal austerity had arrived in Washington, and no more projects were ever funded. Five of the six were terminated in 1982, and one continues to the present. For this reason, the data base considered by the Committee and framers of PRIA to be adequate for formulating a sound management program only became a limited reality.

In Phase III, the Committee combined selected information from the Phase I report, what it could glean from the Phase II research, material from BLM and FS files, and publications between 1980 and 1982 to produce a limited final report (Wagner et al. 1982) directed largely to a number of management questions.

Equid Niches: Potential for Competition

Horse and Burro Distribution

The wild horses on national forest and BLM lands in the western United States are largely animals of the higher-latitude, "cold" desert regions. The five states with the most animals, in descending order, are Nevada, Wyoming, California, Oregon, Utah (Figure 1). The 27,189 horses in Nevada constitute 59 percent of the total.

Burro distribution is more southerly. The "hot" deserts of southern California and Arizona afford habitat for 88 percent of the animals in the West, and southern Nevada contains most of the remainder (Figure 1).

Two factors, one ecological and one administrative, appear to account for these distributions. Domestic horses, and the contemporary feral animals we call wild horses, are the descendents of the truly wild Przewalski's horse of the Asian and European steppes. Thus, wild horse distribution in the sagebrush steppes of North America is an analog of their ancestral biogeography. The domestic donkey is descended from the African wild ass *(Equus asinus),* originally of the low-latitude (10°N) arid regions of northeastern Africa. Hence, the distribution of southwestern burros also reflects their biogeographic ancestry.

However, the distributions also reflect the amount of public land available for wild equids. The six states containing the largest numbers of horses and burros are among the seven states in the lower 48 with the largest amount of public land. It is no mere coincidence that Nevada, with 86 percent of its area in public land, should hold 58 percent of the wild horses and 11 percent of the burros resident on national forest and BLM lands in the western states.

Dietary Preferences

Horses. Horses are primarily grazers, with a strong preference for grasses. One southern New Mexico study (Hansen 1976) found grasses making up only about half of the year-round diet, the remainder roughly divided between forbs and browse. But five studies in more typical horse range farther north (Colorado, Wyoming, Alberta, and Oregon) found grasses comprising well over 90 percent of

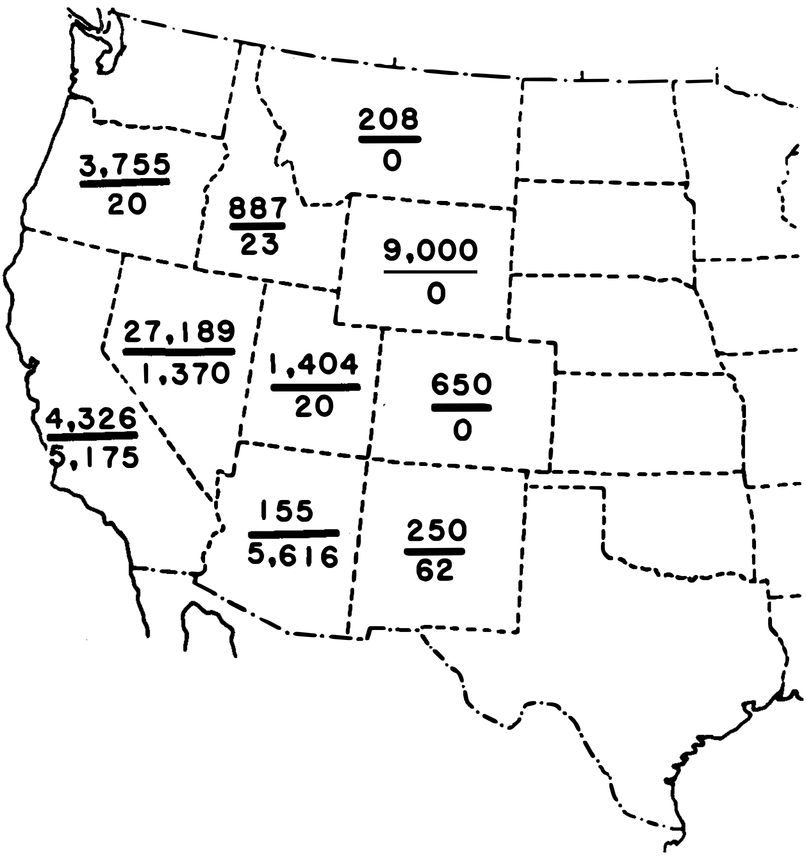

Figure 1. Estimated numbers of wild horses (upper number) and burros (lower number) in 1982 on national forest and Bureau of Land Management lands in the western United States. The data are from Anon. (1982).

the year-round diet (Hubbard and Hansen 1976, Hansen et al. 1977, Olsen and Hansen 1977, Vavra and Sneva 1978, Salter and Hudson 1979).

A study of the dietary preferences of sympatric horses and cattle was contracted to investigators at the University of Wyoming as part of the Phase II research. This study showed grasses making up about two-thirds of the horses' diet, with low shrubs constituting a fourth to a third, somewhat higher than most other studies (Krysl et al. 1982, Smith et al. 1982).

This predilection for grasses correlates closely with cattle dietary preferences, as several studies have shown (Olsen and Hansen 1977, Hansen et al. 1977). The Phase II Wyoming study showed 80–88 percent overlap of plant species in the diet of both horses and cattle in winter, 71–73 percent in summer. It is this similarity that has aroused the concern of cattlemen.

There is also dietary overlap with grazing wild ungulates, particularly elk *(Cervus canadensis)* (Olsen and Hansen 1977, Hansen and Clark 1977, Salter and Hudson

1980) and bighorn sheep (Peek, in Thomas 1979). The diet of a grass feeder would, however, complement that of predominantly forb and browse feeders. Thus, in three Colorado studies, horse and mule deer *(Odocoileus hemionus)* diets generally overlapped by less than 5 percent (Hubbard and Hansen 1976, Hansen and Clark 1977, Hansen et al. 1977). Similarly, Olsen and Hansen (1977) found little dietary overlap between horses and pronghorns *(Antilocapra americana)* in Wyoming.

On degraded range, the plant species preferred by grazers and browsers might be depleted to the point where the food habits of both would converge. In this case competition could occur, a condition observed by Forrest Sneva (pers. comm.) between horses and mule deer in overutilized range in Oregon. Similarly, severe winter weather can reduce vegetation availability and force together species that normally feed in different habitat and/or on different plant species. Thus Miller (1980) observed the convergence of horses, cattle, elk, and pronghorn along ridges when deep snow buried much of the vegetation on more gentle terrain.

Burros. The diets of feral asses cover a considerably broader spectrum than those of horses. Green grasses and forbs appear to be preferred when available (Hansen and Martin 1973, Woodward and Ohmart 1976, Ginnett 1982), but on an annual basis browse predominates in most of the diets that have been studied (Browning 1960, Seegmiller and Ohmart 1976, Jordan et al. 1979, Ginnett 1982).

Burros are less numerous and widely distributed than wild horses, and occur in poorer cattle range. Hence there has been less concern for dietary overlap and possible competition with cattle. The greater concern has been in wildlife circles over competition with desert bighorn sheep. Diet studies on sympatric burros and bighorns have shown year-round dietary overlap ranging from 47 (Seegmiller and Ohmart 1981) to 67 percent (Ginnett 1982). Morgart (1978) observed some overlap in winter diets between burros and mule deer in New Mexico.

Forage Consumption Rates

The caecal digestive system in equids is less efficient than the ruminant system of bovids and cervids. Viewed from the standpoint of an equid struggling to meet its nutritional needs, the animal must compensate by greater forage intake rates and faster flow of ingesta through the gastro-intestinal tract. In allocating forage to livestock and horses on public ranges, BLM has used the rule of thumb that an equid will consume 1.25 times as much forage as a cow of similar weight.

In an attempt to derive actual measurements of this differential, a Phase II research project was contracted to investigators at Colorado State University. In the course of this study, mares on the average consumed about 14 percent more forage dry matter than cows of the same weight, while lactating mares consumed 20 percent more than lactating cows (Rittenhouse et al. 1982). These differentials may be somewhat conservative, according to the researchers, and hence the work lends some support to the BLM 1.25 rule.

Viewed from the standpoint of herbivores seeking their nutritional needs from low-quality forage, caecal digestion may give equids a competitive advantage over ruminants. The amount of forage that can be consumed by a bovid or cervid is limited by the capacity of the rumen and the rate at which the contents are processed and passed on. In an area with low-quality forage that has low nutritional content, the ruminant might not be able to ingest enough per unit of time to meet its nutritional need. The equid, with faster flow-through, can apparently eat more of the same forage and accumulate its aggregate nutritional need (Robinson and Slade 1974, Hintz et al. 1978).

Those observers concerned about burro and desert bighorn competition have suggested that the sheep may suffer as a result of these digestive differences. Burros can presumably survive on lower-quality plant species while at the same time eating the more nutritious ones needed by sheep, thereby surviving under marginal conditions rendered intolerable for the sheep.

Habitat Preferences

Horses. Even though two species may consume the same types of food, competition may be reduced or avoided if they partially or wholly occupy different habitats. Several cases of habitat segregation between horses and cattle have been reported. One was shown to the N.A.S. Committee by Martin Vavra in the Three Fingers Herd Management Area, Shepherd Mountains of eastern Oregon. Horses largely occupied mountain-top terrain, while cattle occurred almost entirely on the lower elevations. Vavra commented that the horse habitat coincided more closely with that of bighorn sheep in the area than of cattle.

Other cases have been reported by Pelligrini (1971) and Wright (1979) for Nevada. In winter, horses sought wind-swept ridge tops. They only coexisted with cattle in the lowlands during summer when both required access to watering areas.

In an effort to explore this phenomenon more fully, a Phase II research project was contracted to scientists at the University of Wyoming. The results (Denniston et al. 1982) were somewhat similar to the Nevada reports. Cattle tended to remain relatively close to water sources year-round. Horses ranged much more widely in fall and winter but, like the cattle, remained in closer proximity to water in spring and summer. But even at these seasons, cattle and horses foraged in somewhat different vegetation types. Pronghorns, on the other hand, exhibited a seasonal distribution pattern in the Wyoming study area much like that of the horses (Denniston et al. 1982).

In general, horses appear more wide-ranging than cattle, and less tied to water. In all of the above examples, with the possible exception of Vavra's, horses ranged over nearly all of the terrain occupied by cattle—though not necessarily at the same time of year—while cattle ranged over only a small portion of the area used by horses. Hence, the problem of allocating forage to the two species is more complex than merely estimating the gross forage demand of the animals on an area, and assuming direct equivalence between the two species in using the forage.

The differences in forage preferences and habitat selection need more extensive study. The N.A.S. Committee recommended several studies, like the Wyoming project, over the West.

Burros. The same considerations of habitat partitioning apply to burros and desert bighorns. Several authors have pointed to differing habitat selection (Sleznik 1963, Jones 1980). Seegmiller and Ohmart (1981) depicted a pattern somewhat similar to that described for horse and cattle overlap. During summer, both sheep and burros tend to converge on the lower elevations near water. But in the cooler months, sheep move onto the talus terrain and long steep slopes, while burros favor the foothills. As in the case of horses and cattle, if competition for forage occurs, it is most likely to take place during the season when both species gravitate to the vicinity of watering areas.

Is There Competition?

In an ecological sense interspecific competition occurs when two species require a resource that is in short supply. If in attaining it either or both species are deprived nutritionally, this constitutes competition. For ecologists, the ultimate criterion is a reduction in birth and/or survival rate, and hence a population effect. But for the livestock rancher, reduced weight gains of his animals might well qualify.

It does not necessarily follow that competition is occurring when two species use a common resource. If the resource is not reduced to the point of affecting one or both species, they do not compete. And the problems of discerning a population effect make it difficult to demonstrate competition unequivocally. Some observers have inferred competition when one species declines in the presence of another, but such cases tend to be circumstantial. Ideally, the case is made when the resource in question and nutritional status of the competitors are measured and population effects are observed under replicated experimental and control conditions.

There have been numerous complaints from stockmen about range severely overused by horses to the detriment of cattle, and the BLM has carried out herd reductions in many of these areas in the past 2–4 years. Horse advocate groups protest that the range impacts could just as reasonably be attributed to the livestock. Indeed, where both livestock and horses use the same habitat, it is almost impossible to separate vegetation effects of the two classes of animals.

Three reported cases of severe vegetation impacts by horses were reviewed in the Phase III report (Wagner et al. 1982:16–17). The NAS Committee asked to be shown areas of severe horse impacts, but was told by BLM that such areas were few and inaccessible. None was seen. Some evidence of former burro damage was observed in southwestern Arizona.

A case for administratively imposed competition can be made. A land-management agency may determine that the vegetation of a given area can accommodate a certain number of Animal Unit Months (AUMs) of forage removal without damage to the range. If the number of animals present is restricted to this number, and it includes some horses, then livestock numbers are reduced accordingly and this is de facto competition. The same holds true for native ungulates if they are factored into the AUM calculations.

Some cases of horse competition with native wildlife have been inferred. Crump (1971) concluded that Rocky Mountain bighorn range in the Wind River Mountains of Wyoming was limited by horse competition, as did Stelfox (1976) for Alberta. Thomas (1979:194) drew similar conclusions for horse impacts on bighorn numbers in the White Mountains on the California-Nevada border.

A large, four-decade literature, reviewed in some detail in the Phase I (Wagner et al. 1980) and Phase III (Wagner et al. 1982) reports, implies burro competition with desert bighorns. Most, though not all, contemporary investigators suspect that competition occurs, and that sheep populations are reduced by the presence of burros. But the evidence is circumstantial and equivocal, and the latest authors

(McCutchen 1981, Seegmiller and Ohmart 1981, Ginnett 1982, Hansen 1982) stop short of firmly concluding that competition exists.

Horse and Burro Populations

Numbers and the Problem of Census

Although BLM has published estimates of horse and burro numbers in the western states since the late 1960s, formal censuses over all of its districts were not begun until the early 1970s. Early counts were conducted with fixed-wing aircraft, while helicopters came into use in the middle 70s.

Agency personnel have generally assumed that their horse censuses were counting virtually all of the animals. But analyses of the BLM census data in the Phase I report (Wagner et al. 1980:55–66, 199–201) speculated on several sources of bias and error. In consequence, a Phase II research project was contracted to investigators at the University of Minnesota to evaluate the censuses employed by BLM and Forest Service.

Studies were conducted in four horse management areas: two in Nevada and one each in Oregon and Wyoming. Samples of animals were marked so that they could be recognized from the air, and standard aerial censuses were then conducted with different types of aircraft and under varying observation conditions. Unexpectedly, the results showed greater visibility when the ground was bare than with partial or total snow cover. And higher proportions of animals were seen from helicopters and slower fixed-wing craft (Piper Supercub) than from faster planes like the Cessna 180 (Siniff et al. 1982).

Most important, the results showed about 93 percent accuracy in areas of low vegetation and moderate terrain. But in wooded and mountainous topography, as many as 60 percent of the animals were missed, even by careful and experienced observers. Hence the West-wide censuses are quite probably conservative, the actual numbers of animals present probably exceeding the agency census figures by some unknown margin.

The project was able to conduct one brief set of observations on burros in Arizona. The results were too preliminary to allow meaningful conclusions. But an earlier study by Ohmart et al. (1978) also had investigated the accuracy with which marked animals were resighted in helicopter censuses. The results suggested only 35 percent accuracy. Burros are difficult to see from the air because of their tendency not to move when aircraft fly over, and because their neutral colors blend into rocky, dull-colored desert terrain with little vegetation.

Rates of Herd Increase

The rates at which horse and burro herds increase have several management implications. One is simply the frequency with which herds must be cropped in order to maintain them at specified levels.

Another relates to the agencies' long-term management goals. There has been some advocacy of reducing horse and burro herds back to the 1971 levels. Hence, cutting back the horse herds from the current 45,000 to the assumed 17,000 in 1971 would entail major reductions.

Agency personnel and other observers generally have claimed that horse and burro populations increase at around 18–22 percent per year. Calculation of increase rates from 17,000 in 1971 to 50,000 by 1980 provides an annual rate of about 16–17 percent.

Approaching the question of increase rates from published information on horse and burro demography, Conley (1979) and Wolfe (1980) calculated annual increase rates from age-specific fecundity and survival schedules. Similar calculations were made in considerable detail in the Phase I report, drawing on published data from seven horse studies, six burro studies, and unpublished BLM data from herd round-ups (Wagner et al. 1980:33–86). All of these calculations produced increase rates well below 16–17 percent per annum, and quite possibly well below 10 percent. Eberhardt et al. (1982) have since reported apparent high increase rates shown by seemingly accurate population censuses in two Oregon areas.

Hence there remains considerable uncertainty on this question. In the final analysis, increase rates probably vary between areas, with annual variations in rainfall, with herd density, and with competition from other herbivores. More research is needed to understand the variations in demographic performance and the factors affecting it.

Meanwhile, if increase rates generally have been well below 16–17 percent annually, BLM's desired 1971 management level is in some question. Extrapolation back from the 1980 census with considerably lower increase rates would imply a substantially higher 1971 population—conceivably double.

Furthermore, the 1971 census quite possibly underestimated the true population size by a larger margin than did the 1980 census. At that time, herds were censused by fixed-wing aircraft, not all areas were being censused, and agency personnel were less experienced. An elevated 1971 population estimate would tend to support the hypothesis of lower increase rates.

The data analysed in the Phase I report suggested that burros commonly foal a year earlier than horses, have slightly higher percentages of jennies foaling, and show higher percentages of foals and yearlings in the herds. All of this suggested somewhat higher increase rates in burros than in horses, but still well below the commonly claimed 18–22 percent.

The Primary Management Dilemmas

Dividing the Pie

The issue in perspective. A look at the total number of equids, livestock, and native ruminants on the western public ranges gives an overall view of the trade-off being made in behalf of the advocates for these three classes of animals, and the magnitude of the problem.

BLM in its annually published *Public Land Statistics,* and FS in its *Annual Grazing Statistical Report,* list the 1980 numbers of large, herbivorous mammals on the lands they administer (USDI-BLM 1981, USDA Forest Service 1981). The totals for the two classes of land combined are:

Wild horses and burros	67,296
Cattle, domestic horses, sheep, and goats	6,578,238
Wild ungulates (BLM only)	1,559,887

Since many of the livestock are not on the public lands throughout the year, and there may be seasonal duplication of livestock between BLM and FS lands, a more accurate and fair insight is gained by comparing the reported AUMs, as follows: (1) FS reports wild equid AUMs directly at 20,200. Multiplying the 64,545 reported equids on BLM land by 12, and adding the FS total gives the aggregate for both kinds of public lands. (2) Livestock AUMs are reported directly. (3) FS does not report wildlife numbers on national forests in the statistical reports. Wild ungulate AUMs on BLM lands can be calculated by (a) assuming that most are mule deer or pronghorn, (b) accordingly dividing 1,559,887 by 5 because of their size, and (c) multiplying by 12 for months of use. The resulting values are as follows:

Wild horses and burros	794,740
Domestic animals	18,631,934
Wild ungulates (BLM only)	3,743,728

Thus, for the total public grazing lands, the ratio of livestock to equid AUMs is 23:1. This could be reduced by assigning 1.25 Animal Units per horse or burro (in comparison with 1.0 per cow), and by correcting horse numbers for the census undercount, if known. But the less-then-perfect correspondence between horse and livestock diets, and the differing habitat preferences offset the greater forage consumption and conservative censuses in terms of direct competitive ratios. Hence, one could reasonably suggest as a first approximation that the forage gained for the western livestock industry by removing equids from the public lands might be on the order of 5 percent.

The ratio of wild ungulate AUMs on BLM lands to total equid AUMs is roughly 5:1. It seems likely that there are fully as many wildlife on the national forests as on BLM lands, and hence the ratio of wildlife to equid AUMs on all public grazing lands could well be 10:1 or more. Since most of the wildlife are deer and pronghorns, whose diets overlap very little with horses, the presence of the latter might in many cases actually increase the forage for these two species through synergistic effects on vegetation. Possible competitive effects with bighorn sheep will be touched on later.

These gross figures are useful in viewing the issue from a national or West-wide perspective. They give some sense of how much the western livestock industry as a whole, or wildlife interests, are trading off in behalf of the mandates of the Wild Horse and Burro Act. And they are useful background data for considering any agency policy of reducing horse and burro numbers to 1971 levels.

But the gross figures also obscure the local, on-the-ground nature of the problem. To begin with, most of the equids are on BLM lands. Since the livestock AUMs on national forests and BLM lands are nearly the same, the ratio of livestock to wild equid AUMs on BLM lands is about half that for all public grazing lands, or perhaps somewhere near 12:1. Furthermore, since Nevada has nearly half of all the equids (Figure 1), state Bureau records show a ratio of about 4.8:1 livestock to equid AUMs. Within the state, this varies from 23:1 in the Elko BLM District (which has 38 percent of state cattle numbers and 6 percent of horses), to 2:1 on the Las Vegas District (which has 5 percent of the state's cattle and 21 percent of the equids). Hence the real trade-offs are likely to be local ones involving small numbers of ranchers. It can hardly be claimed to be a significant industry-wide or West-wide problem.

The range capability. The Public Rangelands Improvement Act of 1978, in discussing wild horses and burros on public rangelands, refers repeatedly to "excess" numbers of equids. It directs the NAS study, which it authorizes, to define "excess"; but it then proceeds itself to provide a definition. That definition contains two basic elements:

1. A concern that the public ranges be managed in such a way that their condition approaches maximum or potential productivity.
2. A concern for multiple-use management and a plurality of resources (livestock forage, wildlife, water, soils, and recreation, as well as wild equids).

The NAS Committee basically accepted these elements in its concept of "excess," but added a biological proviso and an additional sociopolitical element. In general, the perspective taken was as follows.

Rangeland vegetation, having evolved with herbivores, is physiologically constituted to withstand grazing or browsing removal. There is an optimum level of herbivory which enables a vegetation-herbivore system to assume some equilibrium state in which the vegetation can support a maximum number of herbivores on a long-term, sustained-yield basis. This level varies from locale to locale, depending on the vegetation type, climate, soils, and topography of each. And the equilibrium is a long-term average one, the actual year-to-year conditions varying widely with annual variations in weather and other factors.

The range can support different species of herbivores and combinations thereof. The total numbers of individuals of several species that can be accommodated depends on the degree of their niche similarity or complementarity. Wild equids fit in this scheme and can be carried in varying numbers depending on whether there are other species of both domestic and wild herbivores present and on their niche relationships.

Some critics of wild equids have suggested that because they are exotics, they can somehow not be carried by the vegetation without damage. But there does not seem to be any evidence to support this view as long as they are not allowed to increase to excessive numbers. Excess native ungulates can obviously damage vegetation, and the ranges in question are, after all, already carrying large numbers of exotic livestock.

In the view of the NAS Committee, then, excess in a biological sense is that number of herbivores which exceeds what the system can carry on a maximum, sustained-yield basis, or irrevocably damages it. This excess could be effected by a single species or some combination.

There is also a sociopolitical connotation to excess. If the presence of a given class of animals results in lower numbers of another class that one interest-group desires, then in the eyes of this group the former are present in excess even though the aggregate number may be within the limits of the system's biological health.

How many should there be? A significant component of the American public, a federal law, and a formal Division of Wild Horses and Burros in BLM now ensure that wild horses and burros shall be considered and managed as part of the natural systems on public rangelands. Hence there appears to be no question about continuing some number of these animals. The real management dilemma facing the agencies is how many there should be and where.

There is no immediately obvious answer to this question. It is not clear that the present populations constitute the appropriate numbers. But it is equally unclear that numbers should be cut back to the 1971 level. BLM officials deny that any such formal policy has been adopted. But the idea of reducing back to 1971 numbers has circulated often enough unofficially that two authors—Ryden (1978:295) and Thomas (1979:139)—have published this as the agency's intent. And in January 1982, BLM included a sheet entitled "Bureau of Land Management Wild Horse and Burro Population Estimates" in a packet of material submitted to the Senate Committee on Energy and Natural Resources. The sheet included a table with columns entitled "Estimated Management Levels" and "Estimated Removals." These totaled 21,215 and 23,715, respectively.

What the Wild Horse and Burro Act does specify is that, as shown in the quote near the beginning of this paper, the animals will be managed in the areas in which they occurred at the time of its passage. Nothing is said about numbers, and one cannot avoid wondering how well even the distribution was known in 1971 before horse and burro management became a formal agency mandate.

In fairness to the agencies, it must be pointed out that decisions on "management levels" are being made for each individual herd management area, and the national target of 21,215 horses is the aggregate of numbers specified for the individual areas. Such locale-by-locale decision making is surely the appropriate way to go rather than setting some gross national total. Yet the similarity between the aggregate for the management areas and the 1971 estimate of 17,300 is curious, particularly since BLM was not able to show the NAS Committee any seriously impacted areas, or make a case for needing more than 50 percent reduction from current levels.

Except possibly in areas designated as experimental wild horse ranges as Ryden (1978:295–296) advocates, the first consideration in setting a desirable "management level" for an area would presumably be the range condition. BLM now manages three wild horse ranges in Nevada, Montana, and Colorado, although not necessarily on a laissez-faire, "natural" basis. Nevertheless, for the public ranges as a whole, the intent of the Public Rangelands Improvement Act is one of maximally productive ranges and multiple use. If a given range is being overutilized and prevented from reaching maximum productivity, some animals must be removed. This need seems clear enough and few of the concerned interests challenge it.

However, the problem arises in deciding whether the animals to be removed should be equids, livestock, or native wildlife, and in what numbers. Such decisions should, in my opinion, be reached in concert with representatives from each advocate group rather than be agency fiat (Wagner 1977). In fact, such concerted decision making is taking place in some areas.

In Nevada, compromises are reached on the desirable number of equids, livestock, and wildlife through the efforts of citizens' groups entitled Coordinated Resource Management Planning Locals (Kenneth S. Sakurada, pers. comm.). There are ten such Locals consisting of individuals from horse advocacy groups, local livestockmen, agency representatives, and other interested people. Coordination is provided by the County Agent, or by a representative from the local Soil Conservation District. The system seems to be working well in this state with over half of the wild horses in the West. But it is not clear whether the area "management levels" prescribed for other states in the document for the Senate Committee were reached by such concerted efforts. In at least one case—Wyoming—they were prescribed by court order.

Cost is another consideration. In a period of governmental fiscal austerity, the cost of rounding up, transporting, holding, and adopting out the annual reproductive increment on a "management-level" population of 50,000 is obviously greater than one of 25,000.

Possible impact on threatened or endangered native species is yet another consideration prompted by the concern for irrevocable damage in the concept of excess. This arises particularly in the case of burro management in desert bighorn range. The NAS Committee was not unanimous in this regard. But a sizeable portion opined that, while burro damage to sheep populations had not been unequivocably demonstrated, the lengthy and prevalent view among those close to the problem argued for caution in behalf of the sheep, and removal of burros from sheep areas. Actually, BLM is already pursuing this policy in the Southwest.

In short, there is no clear answer to the question of how many equids should be managed on the public ranges. The Wild Horse and Burro Act specifies that they are to be managed in areas in which they occurred at the time of its passage, but not how many. Subsequent legislation decrees that they are to be managed in a multiple-use context on ranges in good condition. Desirable numbers should become a matter of compromise between contending groups on a locale-by-locale basis.

Population Control

Adoption program. Along with the question of numbers, the procedures for maintaining populations at "management levels" is another dilemma facing the agencies, and the problem is primarily one of cost. The Adopt-a-Horse and Adopt-a-Burro Programs have been well received by the wild horse and burro advocates. Procedures have been well worked out by the agencies. Elaborate adoption centers have been constructed in California, Oregon, Nevada, and Wyoming, with temporary centers in Arizona, California, Colorado, Idaho, Montana, Oregon, and Utah. It was with these procedures and facilities that 29,977 horses and 5,088 burros had been adopted by 1981, and a long waiting list of potential adopters assured a continued outlet for annually captured animals.

However, the average adoption fee of $62 received in 1981 fell far short of the average cost per animal of roughly $500 (Anon. 1982). Hence, in January 1982 the agencies raised the fees to $200 per horse and $75 per burro, plus transportation costs, to make the program more nearly self sufficient. With this change, the adoption demand sagged, and the agencies no longer had an outlet for the annual increment to populations of the early 1980s, much less the larger numbers they proposed to remove to reach "management levels."

In order to get around this problem, an amendment to the Wild Horse and Burro Act was introduced in early 1982 as S.2183 and H.R.5825 that would allow sale of animals in excess of adoption demand, something not permitted by the original Act. Horse and burro advocates were generally concerned about this change, fearing that animals so purchased would end up in foreign meat markets or pet food plants. Indeed, the amendment explicitly removed the wording in the original Act which prohibited selling or transferring horses or burros, or their remains, for processing into commercial products.

The amendment was never acted upon by the 97th Congress, and the problem remains. (In early March 1983, after this paper was written, BLM reduced the horse adoption fee to $125, and adoption requests appear to be on the rise again.

Whether or not this will be sufficient remains to be seen. Meanwhile, legislation similar to S.2183 and H.R.5825 is once again being introduced.)

Fertility control. As an alternative to round-ups, some consideration has been given to administering steroids to reduce fertility, both in stallions and mares. BLM supported one project by investigators at Eastern Montana College which explored the possibility of chemosterilizing stallions in an Idaho area. Testosterone propionate dosages were administered by dart gun to dominant band studs from helicopters. The results of this small study (7 studs were treated) were positive, the 30 mature mares in the experimental bands producing only 2 colts in the following year (Kirkpatrick et al. 1981). However, the NAS Committee marshalled a large amount of evidence (Wagner et al. 1982:50–51) indicating that the necessary conditions for the technique to succeed—all breeding within a band carried out by the dominant stud, and no exchange of mares between bands—do not generally prevail. It concluded that the technique did not have promise as a West-wide, population-control measure.

Fertility control in mares has not received concerted attention. The Committee opined that it had promise and merited study. One small study associated with the Phase II census research project experimented with immobilizing mares with dart guns from helicopters. Animals captured in this way could be given steroid implants for fertility control. Average cost per animal over a sample of 87 was $225.70, and it is theoretically possible to sterilize a mare for more than one year.

Conclusion

In my own view, the agencies have generally done a satisfactory job in meeting the mandates of the Wild Horse and Burro Act. Through much of their organizations, there appears to be a genuine commitment to manage equids as ". . . an integral part of the natural system of the public lands." The commitment is not universal, and the NAS Committee did at times encounter negative attitudes toward the animals in the Bureau, doubtless reflecting long association with livestock interests and attitudes.

The present number of equids accounts for a small fraction of the total, herbivorous forage removal on the public rangelands. Although there may be local problems of excessive use, the areas shown the Committee and attitudes of BLM officials with whom it interacted did not give any impression of widespread overuse. Hence, the reason for the Bureau's stated intention to reduce equid numbers by more than half is not entirely clear. It might be justified, but the action should, in my opinion, be taken openly and with input from all the concerned interests rather than by internal agency decision.

The adoption program was working well. While the $4–7 million cost of recent years was of some consequence, it is not clear why this program should be any more self-supporting than a national park or wildlife refuge. Some economies appear possible. BLM (Anon. 1982) reports that removal costs are declining as round-up and adoption procedures become more standardized and efficient, and some are contracted to private individuals. The NAS Phase III report recommended that herds be censused no oftener than every other year and concurred with agencies' practice of rounding up individual herds once every few years. The Committee also recommended independent economic analysis to explore possible economies, but no such projects were ever undertaken.

It does seem important that the agencies have some machinery for controlling population growth. If populations are not now generally in excess, that situation could change following a few years of uncontrolled increase. If adoption demand were to fall off, even with the previously modest adoption fees, then some sort of sales provision, like that of the McClure amendment (S.2183), might be needed. Meanwhile, alternative control measures, like chemosterilization, could well be explored.

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Managing Central Hardwood Forests: Partnership and Model Approaches

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While the title applies specifically to managing central hardwood forests, the paper deals more specifically with the subtitle: partnership and model approaches. Many of these same approaches would be appropriate if the habitat involved was wetland or grassland and, in fact, much of the information developed from these partnerships is applicable to most habitat types. The problem associated with restricting these partnership efforts to a single habitat type represents a fragmented approach and implies a fragmented responsibility. Our partnerships and what we believe are model approaches to wildlife management do not accept as discrete, forest versus openland wildlife. In fact, a high percentage of Missouri wildlife species are species of the edge and consequently require the management of both forested and non-forested habitat.

The agencies involved in these cooperative approaches are not discrete in these presumed separated interests in forest versus non-forested landscapes. The Soil Conservation Service (SCS) gathers data and gives landowners recommendations on forests as well as grasslands and cropfields. The U.S. Fish and Wildlife Service (FWS) is well known for their wetland interests for waterfowl but they also manage thousands of acres of forested habitat and have national responsibility for threatened and endangered species. The U.S. Forest Service (FS) has the responsibility to manage their forested landscapes as well as their non-forested areas. The Office of Surface Mining (OSM) is responsible for reclamation on forested as well as non-forested sites. The Bureau of Land Management (BLM) has an interest in mineral extraction from all public lands (forested and non-forested) and manages lands of its own that are both forested and non-forested. For these reasons the discussion of "partnerships and model approaches" covers more than the title of "managing central hardwood forests" implies.

Even if we tried to deal solely with the hardwood forest we find difficulties because the forest grades from unbroken tracts of total forest cover to slightly more open to semi-open and finally to grasslands, with some wildlife species dropped and new ones picked up as the relationship between trees and fields changes. Interspersed throughout the mixed landscape are streams and riparian zones of great diversity that cannot be treated separately from the forested landscape.

Federal laws and regulations (Resources Conservation Act, Resources Planning Act, National Environmental Policy Act, National Forest Management Act) have all tremendously increased the need for biological information and a system of handling that information so that it can be an integral part of the decision-making process. These federal laws and regulations require certain fish and wildlife information, but the job of providing that information invariably falls upon the states, usually the state fish and wildlife agency. It seems reasonable and fair that a partnership with cooperative funding and cooperative decision making develop among the states and the federal agencies.

Much progress has been made since the early 1970s when the Department of Conservation in cooperation with the National Forests in Missouri developed the *Wildlife Habitat Management Guide for the National Forests in Missouri,* followed by a management program (Evans 1974) that became the national model for Sikes Act projects.

Initially, the management of any habitat must be based upon the recognition of the species involved. Our first task was to develop a list of species that occur in Missouri and reach agreement on that list. This list in itself was no small task and was accomplished as a cooperative effort with the Mark Twain National Forest. The group of experts agreed that the vertebrate wildlife species of Missouri (Kelly 1979) include: 88 reptiles, 48 amphibians, 375 birds, 76 mammals, and 204 fishes, for a total of 791 vertebrate species.

This species list then provided the basis for the next step in the partnership approach, "A Procedure for Describing Fish and Wildlife" (Mason et al. 1980). "Procedure" is an EDP booklet format developed by the Eastern Energy and Land Use Team of the FWS. The booklet includes data fields for recording information on life history, distribution, population trends, niche and habitat requirements, and approximately 85 additional data fields of information. A booklet will be completed on each of the Missouri vertebrates along with approximately 200 invertebrates including Niaids, snails, crayfish and aquatic insects. Agencies involved in this partnership include SCS, FS, FWS, BLM, and OSM. Through this partnership, all involved agencies will use this information to meet state and federal requirements. More up-to-date information will be available for each agency at a lower cost than if each agency acted independently. The responsibility for the wildlife data base remains with the state, as it properly should, while the cost of developing and maintaining it is shared by the agencies needing and requesting information.

"Habitat Evaluation Procedures" (Daniel and Lemaire 1974), in use by the FWS, had its genesis in Missouri from a partnership between the Missouri Department of Conservation and the SCS. Its first perceived use was for water resource project evaluation. Today in Missouri, it has been tailored for use by the SCS in the National Resource Inventory. For Missouri, that National Resource Inventory will include data from each Primary Sample Unit on habitat quality and quantity related to land use trends. HEP has also been tailored to measure the effects of soil conservation practices on wildlife habitat.

The National Forest Management Act and its regulations require the selection and use of Management Indicator Species to guide forest management and the development of standards and guidelines for wildlife. The Missouri Department of Conservation and the Mark Twain National Forest, while working on the new Forest Plan, developed a step-down planning process that involved the process of habitat pattern recognition (PATREC, Williams et al. 1977) to choose 16 indicator species. The guilds, niches, and other life history requisites of these indicator species are calculated to represent the life history requisites and impacts of management on the remaining terrestrial wildlife. Standards and guidelines for the new Forest Plan will insure that habitat requirements are met to maintain a minimum viable population of all species.

Throughout the cooperative process of forest planning, areas of special concern were identified. The partnership with the Mark Twain National Forest includes ad hoc working committees dealing with these subjects: Snags and den trees, dead and down woody material, roads and wildlife, and forest fragmentation. For example, 16 people from the Mark Twain and the Department of Conservation are working as a committee attempting to deal with snags and den trees and dead and down woody material.

Snags and den trees are used by 89 species of wildlife, while 66 species use dead and down woody material. Will this material be available in future even-aged stands? What will be the impacts of firewood cutting? If future den trees are to be left in clearcuts should they be singly or in clumps? That committee is making progress with these questions and others.

Discussion of the impacts of road construction and reconstruction on wildlife and wildlife habitat has ebbed and flowed for the past several years. Today it appears to be reaching a new pitch of concern. The Southeastern Association of Fish and Wildlife Agencies as a group and working through the Forest Service Regional Office, individual states and National Forests is attempting to bring new light on the subject. The timing of this endeavor is particularly critical in view of the timetable for the issuance of new Regional and Forest Plans.

Much work and much speculation has been done nationally on the concepts of island biogeography and the impacts of forest fragmentation. We are preparing a research project to define more clearly the impacts of forest fragmentation and try logically to deal with the question of how our management practices contribute to forest fragmentation and as another criteria to guide our land acquisition program.

This multitude of efforts in partnership and these innovative approaches merely represents the mutual recognition that, as agencies, we are all in the same boat—we form partnerships or we make limited progress. Missourians are stubborn, but we are also the Show-me State. We have shown and been shown that partnership and innovative approaches to natural resources management are the truest measure of commitment.

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How the U.S. Fish and Wildlife Service is Meeting the Challenge of a Reduced Federal Budget

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In 1980, the Nation's voters signalled their intent to change the course of American government, and specifically to see a reduction in Federal spending. The need to reduce the Federal deficit and the size of the Federal government was soon translated into reduced personnel and funding for most agencies, including the Department of the Interior, and for the Fish and Wildlife Service. Our challenge was clear: we must do our work with less resources, operate efficiently, and demonstrate accountability. To ensure that "real" rather than "perceived" change did indeed occur, we implemented an internal management system. Departmental goals were translated into specific, measurable Service objectives.

The Fish and Wildlife Service adjusted to an 11.0 percent reduction in total funding and a 9.7 percent reduction in personnel ceilings between 1981 and 1982. These cutbacks and reductions came at a time when their effects were magnified by inflation. Normally we would be working with increases to at least maintain a status quo, but instead, we have had to adjust and draw inward at nearly all levels of our operation. However, we consider these adjustments to have certain positive aspects in the sense that they promote improved efficiency and accountability in our management of national fish and wildlife resources.

Several positive changes have taken place. Evidence of improvement is apparent in several areas: organizational restructuring, trimming budgets, improved management techniques, and policy updating and revision. Here are some examples:

Organizational restructuring. To improve our efficiency and shorten the chain of command, the 18 Area Offices were eliminated and Regional Offices were restructured. Liaison and responsibility for field support were assigned to our Regional Offices at existing funding levels. Many of the Area Office positions were transferred to field stations.

The Offices of Biological Services, Extension Education, and Research were merged to become Research and Development, assuring improved management control and coordination and flow of information. We also reorganized Law Enforcement Districts, reducing them from 12 to 7. Washington Office and Regional Office staffing were reviewed and administrative positions were eliminated, thereby minimizing the necessity of reductions at the field level.

Budget reductions. The above changes were and are being completed with reduced funding. We have cut back in several areas: Legislative Services, Public Affairs, and Fish Hatcheries, for example. Basic responsibilities have been retained in all program areas.

The Fiscal Year 1983 Interior Appropriations Act called for the closing of twenty national fish hatcheries in 1983, along with 11 fishery assistance stations and 5 research stations. Hatchery facilities are being made available to individual States through a Memorandum of Agreement if they wish to take over the operation.

Several hatcheries have been turned over to States, and we are negotiating similar agreements with other States.

Improved management. The Service has employed several management techniques to deal with budget and personnel cuts. Examples include an employment or hiring freeze and the use of a personnel placement pool to allow the best use of our work force. We are continually monitoring personnel needs and use throughout the year. In this way we are more effectively managing our personnel ceiling allotments.

Policy updating and revision. Vigorous pursuit of a "good neighbor" policy with the States, particularly in the field of wildlife management, was one of our important changes. We have developed a Departmental Fish and Wildlife Policy. The policy covers State-Federal relationships, clarifies and reaffirms Federal and State responsibilities, underscores the importance of existing cooperative agreements, and pinpoints new areas for such agreements. In addition to the Department of Interior Fish and Wildlife Policy, the Animal Damage Control Policy was updated to reflect broader interests, preserving wildlife values while supporting more flexibility in predator management. Also a draft plan was completed to transfer the management of Alaskan marine mammals to the State of Alaska.

Reauthorization of the Endangered Species Act has been accompanied by "streamlining" of certain features of the Act. There was a healthy "give and take" attitude by all parties during the passage of the Act by the Congress. Examples of streamlining include Section 7 (consultation) provisions to (1) maintain 90-day turnaround time for issuing biological opinions, and (2) expedite energy and mineral-related consultations. A record number of 29 endangered species recovery plans were approved in calendar year 1982, plus 75 that were under review and pending approval.

Results of change. Reductions in funding and personnel ceilings are not without some negative aspects, such as facility closures and loss of personnel. We believe we have minimized impacts and have experienced benefits in some cases. We have made changes and adjustments as described. We have asked ourselves what activities could be given up and which ones could be better or more logically completed through increased State-Federal partnerships (such as animal damage control operations in the West, and in the transfer of fish hatcheries to States). Some of our work and responsibility can be completed through contracts. This is especially true where we do not have sufficient personnel within the Service, as in the completion of endangered species recovery plans.

We want to change those individual and group approaches of doing some things the same way just because that is the way we have always done them. We are looking for new ways to do business. We have a slimmer, and we feel more efficient, organization. We will be better off going into the future with the flexibility to adapt and use new technology, new skills, improved communications, and improved planning for the future. The top managers are working as a team in our program management system of operation. We are becoming more responsive in pulling together for common goals.

The Fish and Wildlife Service is meeting the challenge of working with less. We have a continuing obligation to do the best job we can with the resources available, year by year. We feel proud of our past and look forward to the challenge of the future.

State Fish and Wildlife Agency Responses to Funding Challenges

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Introduction

A common problem of state wildlife agencies appears to be adequate funding. From discussions with states and articles in agency magazines, it is apparent that many efforts have been and are being made to secure additional funding. The purpose of this paper was to compile the many types of funding efforts being made in the states into an "idea package" that would make each state aware of all the other states' efforts.

Methods

A questionnaire asking for (1) a list of current funding sources, (2) a list of new sources attempted or proposed and (3) ideas for additional funding sources under consideration was mailed to each fish and wildlife agency. Responses were received from 47 of the 50 states. For the purpose of this survey, funding sources were broken down into three types: (1) traditional sources, (2) federal sources and (3) non-traditional sources. The 47 states responding reported a total of almost $1.2-billion of income that averaged $25.5-million per state.

The terms "current income" and "potential income" were used to analyze funding sources. Current income refers to actual revenues currently being received. Potential income refers to hypothetical revenues from sources that are not being received in some states, but are being received in other states. For example, one-half of the states currently receive income from depository interest on their unspent funds, while the other half does not receive revenue from this source. Current income being received by 25 states for depository interest on reserves would be potential income for the other 25 states.

Findings

Traditional Funding Sources

Traditional sources were defined as revenues from activities, services, properties and surpluses directly related to wildlife agencies and state legislative appropriations. The states derive 68 percent of their funds from traditional sources. Almost $800-million were received. Over half, 51.5 percent, was received from license and permit sales. Another one-third, 34 percent, came from legislative appropriations. The remaining one-third came from 27 different sources, each comprising only 0.08 to 2.27 percent of total income. The 29 different kinds of traditional sources and amounts received from each appear in Table 1. Several very interesting characteristics became apparent when revenue, percentages, agencies, and funding frequencies were added to Table 1. The only so-called traditional state source of

Table 1. Traditional funding sources for state wildlife agencies.

Source	Total revenue	Percentage of traditional funding source	Average amount received by states reporting	Number of states reporting funds[a]
License and permit sales	$411,006,812	51.46	$ 8,744,825	47
Legislative appropriation	278,960,089	34.93	9,619,313	29
Contributions and donations	1,201,153	.15	38,746	30
Boat registration fees	16,670,439	2.09	694,601	24
Commercial fishing	9,423,427	1.18	392,642	24
Fines, confiscations	6,731,133	.84	181,922	37
Fish kills	2,009,900	.25	154,607	13
Noxious vegetation control	634,115	.08	158,528	4
Sale of timber	4,874,496	.61	187,480	26
Sale of agricultural crops	2,255,891	.28	118,731	19
Sale of minerals	5,870,163	.74	652,240	9
Sale of surplus materials	2,214,142	.28	82,005	27
Rentals and miscellaneous sales	7,675,513	.96	196,808	39
Depository interest on investments	18,156,254	2.27	726,250	25
Conservation education camp fees	437,442	.05	109,360	4
Magazine subscriptions	6,171,948	.77	212,875	29
Cost transfers	1,534,151	.19	306,830	5
Environmental license plate fund	1,021,534	.13	510,767	2
Energy and resource fund	1,298,000	.16	1,298,000	1
Miscellaneous income	2,785,834	.35	116,076	24
Reimbursement for free license	486,000	.06	486,000	1
Local government grants	1,112,873	.14	1,112,873	1
Capital bond appropriations	900,003	.11	450,001	2
Grazing leases	1,007,886	.13	335,962	3
Sale of wildlife	806,885	.10	134,480	6
Firearm owners ID	682,977	.09	682,977	1
Camping and day use fees	8,998,215	1.13	1,499,702	6
Sale of tree seedlings	2,435,529	.30	270,614	9
Habitat stamp sales	1,322,985	.17	1,322,985	1
All states[a]	$798,685,789	100.00	$16,639,287	47
		Ideal potential	$30,798,200	

[a]Arkansas, Connecticut and Indiana did not respond to survey.

funds common to all states was revenue from license and permit fees. The second most common revenue came from rentals and miscellaneous sales, 39 states; and fines and confiscations, 37 states. The second most common source combined comprised less than 2 percent of total revenue. The highest average revenue from any single source was not licenses and permits, as suspected, but general fund appropriations. However, only 29 of the 47 states reported receiving funds from general appropriations.

Because of the great dissimilarity in traditional state sources from one state to another, there appears to be many sources with an established precedent in some states that could easily be initiated in other states to yield from $82,000 to $9.6-million dollars annually. If every state were to implement traditional funding sources that are currently being used in all the states, the average annual income of state wildlife agencies from traditional sources would increase from $16.3-million to $30.7-million.

Federal Aid Funding Sources

Federal aid sources were defined as revenues received from the federal government for services, grants, and federal legislative acts and appropriations. Federal aid sources accounted for 20 percent of wildlife agency revenues. The largest source of federal aid was Pittman-Robertson funds, accounting for one-third of all federal revenue. Dingell-Johnson was second, contributing 12.5 percent of the total. The Heritage Conservation and Recreation Service and EPA were the other major contributors, contributing 11.2 and 8.9 percent respectively. The remaining one-third came from another 38 federal sources ranging from 0.01 to 5.7 percent of the total (Table 2).

The average federal income to agencies was $4.9 million. If all the states received the average of all federal income reported, average federal aid would increase to $20.3-million.

Non-Traditional Sources

Non-traditional sources were defined as revenues derived from ad valorem taxes and other state taxes on commodities, renewable and non-renewable resources, property, payroll, sales, wagering, and corporations. While relatively new on the scene, non-traditional sources now contribute 12 percent of total income to state wildlife agencies. The average income from these sources in the 25 states reporting them was $5.6-million. Over one-half of the revenue came from two sources in two states, each contributing 25 percent—the tobacco tax in Texas and the percent of sales tax in Missouri. Another 15 percent came from the forest mill tax in Wisconsin. Other significant contributions were the property tax in Wisconsin, the oil and gas tax in Louisiana, and the bonding authority in Wisconsin, 11, 7.6 and 7.5 percent respectively. The other 15 percent came from 12 other sources, each comprising between 0.04 and 4.4 percent of the total (Table 3).

The most interesting characteristic of non-traditional funds is that if all the states received the average income of only those few being reported now, the average agency income would be $129.4-million.

Table 2. Federal aid funding sources for state wildlife agencies.

Source	Total revenue	Percentage of traditional funding source	Average amount received by states reporting	Number of states reporting funds[a]
Pittman-Robertson Act	$ 76,921,742	32.29	$ 1,672,211	47
Hunter Safety	5,295,815	2.22	155,,759	34
Dingell-Johnson Act	29,794,755	12.51	677,153	47
Nongame	673,089	.28	168,272	4
Endangered Species	3,782,190	1.59	135,078	28
Soil Conservation Service	141,408	.06	23,568	6
Corps of Engineers	7,056,854	2.96	504,061	14
Bureau of Outdoor Recreation	14,129,631	5.72	2,018,518	7
HCRS	26,636,066	11.18	3,805,152	7
CETA	3,034,785	1.27	252,898	12
YACC	7,337,884	3.08	667,080	11
Environmental Protection Agency	21,268,622	8.93	2,658,577	8
U.S. Forest Service	9,158,138	3.84	538,714	17
Bureau of Land Management	1,142,828	.48	190,471	6
Historical Preservation	1,502,764	.63	751,382	2
National Marine Fisheries	3,700,125	1.55	462,515	8
Pacific NW Regional Commission	496,624	.21	165,541	3
Bureau of Reclamation	2,672,356	1.12	381,765	7
Emergency Assistance Act	598,560	.25	99,760	6
Other Federal Agencies	7,408,304	3.11	493,886	14
Commercial Fishing	2,934,720	1.23	163,040	17
Defense	65,000	.03	65,000	1
Indian Affairs	19,000	.01	19,000	1
NOAA	615,738	.26	153,934	4
U.S. Fish and Wildlife	2,039,487	.85	254,935	7
Marine Mammal Protection	96,000	.04	96,000	1
Anadromous Fish Act	2,088,921	.88	208,892	10
Coastal Zone Management	2,825,267	1.19	470,877	6
Coastal Fish Management Act	943,983	.40	188,796	5
TVA	9,924	.00	4,962	2
Surface Mining	150,249	.06	75,124	2
HEW	22,801	.01	22,801	1
HUD	443,319	.19	221,659	2
YCC	570,731	.24	570,731	1
Coast Guard	43,739	.02	43,739	1
Outer Continental Shelf	65,782	.03	65,782	1
Agriculture	18,973	.01	9,486	2
Water & Power Resource	582,660	.25	291,330	2
Coastal Plains Regional Commission	96,921	.04	96,921	1
Animal Damage Control	550,842	.23	275,421	2
Criminal Justice	1,199,655	.50	599,827	2
National Parks	597,360	.25	597,360	1
All states[a]	$238,733,612	100.00	$ 4,973,616	47
		Ideal potential	$20,317,978	

[a]Arkansas, Connecticut and Indiana did not respond to survey.

Table 3. Non-traditional funding sources for state wildlife agencies.

Source	Total funds received	Percentage of non-traditional funds	Average revenue for states reporting	Number[a] of states receiving revenue	Number[a] of states reporting tax
Commodity taxes					
Alcohol	0	0	0	0	21
Tobacco	$ 35,448,240	25.08	$ 35,448,240	1	24
Soft drink	0	0	0	0	1
Fuel	1,536,038	1.96	384,009	4	25
Marine fuel	6,211,151	4.43	621,115	10	22
Snowmobile registration	1,459,519	1.04	729,759	2	2
Ammunition	175,675	0.12	87,837	2	2
Motorcycle	382,302	0.27	382,302	1	1
Severance taxes					
Minerals	0	0	0	0	7
Oil/gas	10,674,890	7.61	10,674,890	1	4
Seafood	86,113	0.06	86,113	1	1
Fur	55,376	0.04	55,376	1	1
Timber	544,180	0.39	544,180	1	6
Gravel, shell, fill	2,241,665	1.60	1,120,832	2	3
Coal	490,378	0.34	490,378	1	4
Forest mill	21,691,296	15.27	21,691,296	1	1
Property taxes					
Real estate transfer	0	0	0	0	8
Property	15,684,930	11.03	15,684,930	1	2
Personal income taxes					
State income	0	0	0	0	26
State income tax check-off	1,732,609	1.23	173,260	10	10
Inheritance	0	0	0	0	6
Sales taxes					
Sales	30,634,032	21.65	30,634,032	1	22
Wagering taxes					
Parimutuel betting	0	0	0	0	8
Lotteries	0	0	0	0	5
Bingo	0	0	0	0	2
Ad valorem taxes					
Recreation vehicle	1,041,998	0.74	520,999	2	11
Motor vehicle	0	0	0	0	2
Boat trailer	0	0	0	0	10
Boat	40,000	0.02	40,000	1	1
Corporate taxes					
Banks and corporations	0	0	0	0	1
Excise insurance	0	0	0	0	1
Franchise	0	0	0	0	1
Bonding authority	10,062,300	7.17	10,062,300	1	1
All states[a]	$140,192,692	100.00	$ 5,607,707	25	48
		Ideal potential	$129,431,848		

[a]Arkansas, Connecticut and Indiana did not respond to survey.

Recent Efforts

A great number of states reported recent efforts to increase revenues. A total of 84 different efforts involving 34 different methods was reported. These efforts and the states reporting them are listed in Tables 4, 5 and 6 for traditional, non-traditional and federal sources respectively. The most commonly reported methods were (1) increasing license fees, (2) state income tax check-off, (3) special use

Table 4. Recent efforts to increase wildlife agency revenue from traditional sources.

Increasing existing license fees (14): AZ; CA; CO; DE; GA; ID; MS; MT; NH; PA; RI; SD; TN; WV.
Special use license (9): AZ–migratory bird, archery only; CA–striped bass; FL–alligator leather products; KS–management area permit; KY–trout; MD–waterfowl stamp; OH–wetland habitat stamp; PA–trout stamp; SC–duck stamp.
General fund reimbursement for free license (6): CA; MA; MT; NE; TN; UT.
Appropriation from general fund (4): OK; TN; VA; WA.
Depository interest on funds (4): KS; MS; MT; ND.
Leasing agency lands for mineral exploration (3): IL; NM; TN.
Increased boating fees (2): GA; SD.
Endowment fund from lifetime license sales (2): NC; NH.
General fund reimbursement for losses incurred from legislative actions (2): NM; NC.
Mass media promotion for contributions (1): NY.
Direct mail solicitation for contributions (1): NY.
Charge consultant fees for information provided (1): SD.
Permit application fee (1): AZ.
Preferred area fee (1): AZ.
Voluntary donation of unsuccessful application fee (1): AZ.
Auction of special use permits (1): NV–bighorns.
Trophy license (1): AZ.
Increased violation fees (1): MS.
Nongame stamp (1): OH.
Hunter education certificate fee (1): FL.

Table 5. Recent efforts to increase wildlife agency revenue from non-traditional sources.

Income tax check-off (12): IL; IA; KS, KY; LA, MD; MA; MI; NH; NY; OH; WV.
Earmarked portion of sales tax (2): MO; WA.
Earmark marine fuel tax (2): SD; TN.
Earmarked endowment fund from mineral severance tax (1): WY.
Off-road vehicle registrations (1): AZ.
Real estate transfer tax involving transactions that will result in loss of habitat (1): AZ.
Mandatory tax surcharge endowment (1): AZ.
Earmarked severance tax (1): CO–oil shale.
Long term leases of state property for concessions (1): IL.
Earmarked portion of power utility funds (1): NY.
Auto license surcharge (2): AZ; CO.

Table 6. Recent efforts to increase wildlife agency revenue from federal sources.

Federal share funding for animal damage control (1): SD.
Contracts with federal agencies for biological surveys (1): SD.
Use of HCRS funds for wildlife (1): SD.

licenses, (4) general fund reimbursement for free licenses, and (5) appropriation from general fund. The other 29 methods were individual efforts being made by a single state.

Idea Package

One of the objectives of this study was to incorporate the results into an "idea package." The great diversification of funding sources encountered and the complexities of detail involved in some of the efforts limited the "idea package" to simply telling what the funding sources and efforts were and crossreferencing these with the state reporting them. This was done in Tables 7, 8 and 9. More information on the various surveys and ideas can be obtained by writing to the individual states reporting them.

Conclusions

The 47 states participating in the survey reported a total of almost $1.2-billion of income that averaged $25.5-million of income per state. Traditional, federal, and non-traditional sources constituted 68, 20 and 12 percent respectively of total income.

The most interesting characteristic of the survey was the ratio of current average income to potential average income for each of the funding sources. These ratios were 1:1.85 for traditional funds, 1:4.08 for federal funds, and 1:23.08 for non-traditional funds. The potential for increasing funding through non-traditional sources was 12 times greater than traditional sources and 6 times greater than for federal sources.

The analysis indicated that the best solution to funding wildlife agencies in the future is through implementation of non-traditional state funding sources such as those being received by a few of the states now. Efforts to increase funding through traditional state and federal sources will only meet short-range needs.

Table 7. States reporting revenue from traditional funding sources.

Source	States[a]
License and permit sales	All states
Legislative appropriation	AL, CA, CO, DE, FL, GA, HI, IL, LA, ME, MD, MI, MN, MS, MT, NE, NV, NH, NJ, NM, NY, NC, OR, RI, SC, TX, UT, WV, WI
Contributions and donations	AZ, CA, CO, ID, IL, KS, KY, LA, ME, MD, MA, MO, NE, NV, NH, NM, NY, NC, ND, OH, OK, PA, SC, SD, TX, UT, VA, WA, WI, WY
Boat registration fees	AZ, CA, GA, IL, IA, KS, LA, ME, MI, MN, MS, MT, NE, NV, NC, ND, PA, SC, SD, TN, TX, VA, WI, WY
Commercial fishing	AL, CA, DE, FL, IL, KS, KY, LA, MD, MN, MO, NJ, NY, ND, OH, OK, OR, PA, RI, SD, TN, WV, WI, WY
Fines, confiscations	AL, AZ, CA, CO, DE, FL, ID, IL, KY, ME, MD, MA, MN, MS, MT, NE, NH, NJ, NM, NY, NC, ND, OH, OK, OR, PA, SC, SD, TN, TX, UT, VT, VA, WA, WV, WI, WY
Fish kills	FL, IL, KY, MN, MS, NC, OH, OK, PA, TN, TX, VA, WV
Noxious vegetation control	AL, FL, MS, WI
Sale of timber	AL, FL, GA, ID, IL, ME, MD, MI, MN, MS, MO, MT, NH, NJ, NY, NC, OK, OR, PA, SC, TN, VT, VA, WA, WV, WI
Sale of agriculture crops	ID, IL, IA, KS, KY, MA, MN, MO, MT, NE, NV, ND, OR, PA, TN, VA, WA, WI, WY
Sale of minerals	IL, KS, MD, MI, ND, OK, PA, TX, WY
Sale of surplus materials	AL, AZ, FL, ID, IA, KS, KY, LA, ME, MS, MO, MT, NE, NH, NM, NC, ND, OH, OK, OR, PA, SC, TN, TX, VA, WI, WY
Rentals and miscellaneous	AZ, CA, CO, DE, FL, GA, HI, ID, IL, IA, KS, KY, LA, ME, MD, MA, MN, MO, MT, NE, NV, NH, NJ, NM, NC, ND, OH, OK, OR, PA, SD, TN, TX, UT, VA, WA, WV, WI, WY
Depository interest	AZ, CA, CO, FL, ID, IA, MA, MI, MS, MO, NE, NV, NH, NM, NY, ND, OH, OK, PA, SD, TN, TX, WA, WV, WY
Conservation camp fees	FL, IA, KY, ME
Magazine subscriptions	AZ, CA, CO, FL, ID, IL, IA, KS, KY, ME, MD, MI, MO, MT, NE, NH, NM, NC, ND, OK, PA, SC, SD, TN, TX, VA, WA, WI, WY
Cost transfers	AZ, CO, ID, WA, WI
Environmental license plate fund	CA, ID
Energy and resource fund	CA
Miscellaneous income	AZ, CO, DE, GA, IL, KS, KY, LA, MD, MA, MS, MO, NH, NY, ND, OK, PA, SD, TN, TX, UT, VA, WA, WV
Reimbursement for free license	CA
Local government grants	WA
Capital bond appropriations	DE, TX
Grazing leases	FL, TX, VT
Sale of wildlife	FL, KY, NJ, OK, WA, WI
Firearm owners ID	IL
Camping and day use fees	IL, MO, MT, TX, WV, WI
Sale of tree seedlings	LA, MS, MO, NH, NC, OK, PA, SD, WI
Habitat stamp sales	NE

[a]Arkansas, Connecticut and Indiana did not respond to survey.

Table 8. States reporting revenue from federal aid sources.

Source	States[a]
Pittman-Robertson Act	All states
Hunter Safety	AL, AK, CA, CO, DE, FL, GA, HI, ID, IA, KS, KY, LA, ME, MD, MI, MN, MT, NE, NV, NH, NJ, NC, ND, OH, OR, RI, SC, SD, TN, UT, VT, WA, WI
Dingell-Johnson Act	All states
Nongame	AZ, MT, NV, WA
Endangered Species	CA, CO, DE, FL, GA, HI, ID, IL, IA, MD, MI, MN, MO, MT, NE, NH, NJ, NY, NC, PA, RI, SC, SD, TN, UT, VA, WA, WI
Soil Conservation Service	AZ, MN, MO, NC, TX, WA
Corps of Engineers	CA, DE, FL, ID, LA, MI, MO, MT, OK, OR, SD, TX, WA, WV
Bureau of Outdoor Recreation	CO, MI, MS, NE, SC, VA, WI
HCRS	DE, IL, IA, MI, MT, PA, TX
CETA	AL, GA, IL, IA, KS, MT, OR, PA, SC, TX, WA, WI
YACC	FL, GA, IL, IA, MI, MO, OR, PA, TN, WA, WI
Environmental Protection Agency	DE, GA, IA, MD, MI, MT, OK, WI
U.S. Forest Service	AL, AZ, CA, FL, HI, ID, IL, IA, MI, MS, MO, MT, NV, NH, OR, WI, WY
Bureau of Land Management	AZ, ID, MT, NV, ND, SC
Historical Preservation	IL, MT
National Marine Fisheries	CA, ID, LA, MN, MS, ND, OR, WA
Pacific NW Regional Commission	ID, OR, WA
Bureau of Reclamation	AZ, CA, FL, ID, MT, WA, WY
Emergency Assistance Act	AZ, FL, MS, MT, SD, VA
Other Federal Agencies	AL, AZ, CA, FL, ID, ME, MT, NM, NY, PA, RI, TX, WA, WI
Commercial Fishing	AZ, CA, CO, DE, IL, KY, LA, MO, MT, NH, PA, RI, SC, TN, TX, WA, WI
Department of Defense	CA
Indian Affairs	CA
NOAA	CA, NH, SD, WA
U.S. Fish and Wildlife	CA, KY, MO, MT, PA, SC, WA
Marine Mammal Protection	CA
Anadromous Fish Act	CA, IL, LA, MA, MN, NH, NY, PA, RI, WI
Coastal Zone Management	DE, LA, MS, PA, RI, SC
Coastal Fish Management Act	DE, MS, NH, PA, SC
Tennessee Valley Authority	GA, TN
Surface Mining	IL, PA
HEW	IL
HUD	IL, WA
YCC	IL
Coast Guard	KS
Outer Continental Shelf	MS
Department of Agriculture	MO, WA
Water and Power Resources	NV, TX
Coastal Plains Regional Commission	SC
Animal Damage Control	SD, WA
Criminal Justice	TX, WA
National Parks	WI

[a]Arkansas, Connecticut and Indiana did not respond to survey.

Table 9. States reporting revenue from non-traditional funding sources.

Source	States[a]
Commodity taxes	
Tobacco	TX
Fuel	MD, MN, MS, MT
Marine fuel	IL, MA, MT, NV, NH, NC, SC, SD, TX, VA
Snowmobile registration	MT, WI
Ammunition	SC, TN
Motorcycle registration	WI
Severance taxes	
Oil/gas	LA
Seafood	LA
Fur	LA
Timber	WI
Gravel, shell, fill	LA, PA
Coal	MT
Forest mill	WI
Property taxes	
Property	WI
Personal income taxes	
State income tax check-off	CO, ID, KS, KY, NJ, NM, OR, SC, UT
Sales taxes	
Sales	MO
Ad valorem taxes	
Recreation vehicle	MI, NH
Boat	AZ
Corporate taxes	
Bonding authority	WI

[a]Arkansas, Connecticut and Indiana did not respond to survey.

Public Financing of Fish and Wildlife Conservation: The California Experience

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Introduction

In 1978 the California Legislature enacted a law that establishes a new funding policy for the State Department of Fish and Game. This innovative law should be viewed as a possible model for other states.

This paper will address three questions. First, what was the nature of California's fish and game funding problem that led to action by the State Legislature? Second, how did the 1978 law resolve this problem? Third, how successful has the law been since its enactment?

California's Fish and Game Funding Problem

Until the late 1960s, the California Department of Fish and Game primarily served two interest groups. The largest group was the sports interests who, in 1969, bought over two and a quarter million fishing licenses and more than three quarters of a million hunting licenses (Anon. 1977). The other group was the commercial fishing industry, which consists primarily of fishermen, processors and dealers. In 1969, license fees from hunters, sports anglers and commercial fishermen accounted for 89 percent of the Department's total budget (Anon. 1977). The remainder was almost exclusively provided from California's share of federal Dingell-Johnson and Pittman-Robertson Act excise tax revenues.[1]

In California, license fees are set by State law. Because of adverse publicity, the State Legislature is reluctant to raise license fees unless unusually serious funding problems arise. Accordingly, license fee increases occurred infrequently.

When fees were raised, a fairly consistent pattern would follow. Fee increases usually resulted in an immediate decline in license sales. However, the larger license fee would compensate for the decline in sales volume so that total revenues remained constant. Gradually, the negative license buyer reaction would subside and revenues increased to the sought-after level. From a total revenue perspective, the Department would shift between being underfunded and overfunded.

While license fees, and consequently most of the source of revenue, increased in a stepwise fashion, the cost of operating existing programs rose steadily. Inflation persistently increased the cost of operating the Department—costs which included personnel, operating expenses and facilities.

The combination of periodic license fee increases and constant inflation resulted in a "boom and bust" cycle for the Department. A period of relative prosperity would follow the fee hike, succeeded by a gradually exacerbating shortfall. Even-

[1]This is revenue returned to the states from the proceeds of an excise tax on hunting and fishing equipment. It is used only for programs relating to hunting and fishing.

tually, the Department was forced into either successfully convincing the Legislature to pass another politically unpopular fee increase or to cut back personnel, defer capital costs and discard low priority programs. Such uncertainty doubtlessly had an unsettling effect on employees. Moreover, most Department programs require staffing continuity over a number of years to be reasonably effective. Unstable revenue sources did not lead to such continuity.

Until the early 1970s, inflation was relatively moderate and the divergence of revenue and costs took place slowly. As a consequence license fee increases were infrequent. In fact, fees were increased in 1958 and then not again until 1972. Soon thereafter, the inflation rate swelled rapidly, precipitating the need for larger and more frequent license fee increases. The boom and bust financial situation was becoming critical.

The funding problem caused by inflation was further compounded by virtue of a number of other factors. For example, the growing decline in hunting license sales reduced Department revenues. Department records indicate that between 1966 and 1976, hunting license sales dropped from over 722,000 to approximately 580,000—a decrease of 19.7 percent (Anon. 1981).

Department license fee revenues also were affected adversely by Legislature's establishment of a free fishing license program. This new social program, started in the 1960s, enabled certain senior citizens, handicapped persons, and disabled veterans to obtain fishing licenses at no cost. Although it is difficult to estimate how many of these persons would have actually purchased licenses, this program probably reduced revenues to some extent.

The cost of new program responsibilities also had a significant impact on the Department's financial condition. In the early 1970s, the Legislature enacted a series of statutes concerned with the management of "nongame" species and with environmental protection. ("Nongame" refers to any species other than those that may be legally hunted or fished.) For example, the 1970 California Species Preservation Act and the California Endangered Species Act require, respectively, the Department to inventory and study rare and endangered wildlife, and to enforce a prohibition on the importation of rare and endangered wildlife into the State. Department biologists must participate on interdisciplinary timber harvest plan review teams under the provisions of the California Forest Practice Act of 1973. The California Environmental Quality Act of 1970 requires the Department to review environmental impact reports on public and (as the result of a subsequent court ruling) private projects that affect wildlife and wildlife habitat. While the Legislature gave the Department these additional responsibilities, it failed to provide sufficient funding for the new programs. The Department was required to finance these programs from its existing sources of revenue.

As a result of the widening gap between its funding capability and overall program responsibilities, the Department sought and received two comprehensive hunting and fishing license fee increases during the early and mid-1970s. By 1978 it was clear that some fundamental changes were needed. Most alarming were the Department's projections that a \$2-million revenue shortfall appeared certain for the coming fiscal year and that, if the trend continued, a \$20-million deficit would accrue by the end of 1983 (Anon. 1977). Only two courses appeared open: either cut back programs and personnel, or increase the license fees again, with further and perhaps larger increases likely to follow.

Sports interests and non-sports interests alike were dissatisfied with the manner in which the Department was funded, although for fundamentally different reasons. Notwithstanding the fact that most licenses were actually less expensive in constant dollar terms in 1978 than they were 20 years before (Anon. 1977), hunters and anglers were unhappy with the large increases in license fees. Moreover, sports interests resented that part of the fees they paid were being used to subsidize free fishing license, commercial fishing, nongame, and environmental protection programs. The cost of commercial fishing programs, for example, exceeded revenues from commercial fishing license fees, permits, and taxes by over $3-million from 1974 through 1977 (Anon. 1977). Much, if not most, of the difference was obtained from hunting and fishing fees. Nongame and environmental programs also benefitted from sports license fees although General Fund[2] appropriations after 1974 helped to defray some of the costs.

The nongame constituencies were also troubled by the funding situation. According to their views, funding for Department nongame and environmental protection programs was inadequate. A major problem was the lack of a directly traceable source of funds for such programs. The Legislature had, at times, provided some General Fund support but not on a consistent basis. Lacking both a specific statutory authorization by the Legislature to use General Fund monies for nongame purposes and a special earmarked source of funds, nongame programs were in jeopardy of being cutback in time of financial crisis. Programs funded from special sources such as hunting, sport fishing, and commercial fishing programs were less likely to be so affected.

One effort was made to raise special revenue for nongame purposes—a fund-raising program in which anyone could voluntarily contribute to the support of the Department's nongame management by purchasing a $5 decal. Unfortunately, very little revenue was raised. Other states have adopted income tax check-off programs and special taxes for nongame and environmental protection, but approaches such as these have not been attempted in California.

The Funding Solution

As indicated above, The Department's funding difficulties were twofold. First, steadily increasing inflation coupled with progressively frequent license fee increases were causing a boom-bust financial situation for the Department. Second, a specific source of adequate funds was not available for conducting the increased nongame, environmental, and free fishing license programs required by the Legislature.

These problems were recognized by the Legislature long before 1978. A number of special hearings were held by various Legislative committees between 1970 and 1978 regarding the funding problem. Yet, probably due to the lack of urgency and disagreement on an acceptable funding plan, little resulted from the hearings.

These circumstances changed in 1978. Faced with a $2-million Department revenue shortfall, the Legislature enacted a measure designed to provide both

[2]The General Fund, as opposed to special funds such as the Fish and Game Preservation Fund, is the depository of most state tax revenues and it used to fund most of the State's activities; special funds contain revenues from specified sources and are used for specified purposes.

short-term fiscal relief and an efficient long-term funding mechanism. The plan was supported by all major Department constituencies.

Like the problem, the enabling legislation (AB 3416; Chapter 855, Statutes of 1978) consisted of two parts. The first part was designed to stabilize license fee revenues. Most fishing, and hunting licenses, permits and stamps issued by the Department were raised to a level sufficient to immediately offset the projected shortfall. Future shortfalls were avoided by automatically adjusting fees each year to an inflation-based index calculated by the California Department of Finance. The "base year" fishing and hunting license prices (1978) established the initial level of sport fishing and hunting program support. In principle, any fundamental change in program levels would require the Legislature to change the base level support provided by the fees by increasing sports licenses beyond that required to offset inflation.

The second feature of the legislative solution was to apportion costs of Department programs equitably between constituent groups. The new law required that funds obtained from hunting and fishing licenses fees be used to finance hunting and fishing programs, that funds from commercial fishing licenses and taxes be used for commercial fishing programs, and that the General Fund would provide the costs of free fishing licenses, nongame programs, and environmental protection programs.

This second provision was essential to reaching agreement on the bill. While all interested parties recognized that the Department was financially troubled, no individual interest group was willing to increase its monetary contribution if another interest group would be the beneficiary. AB 3416 assured each group that this would not happen.

Moreover, nongame interests also benefitted from this new funding arrangement. As mentioned above, pre-AB 3416 nongame programs were funded by a combination of fishing and hunting license fees and *ad hoc* appropriations from the General Fund. If program reductions were to result from insufficient license fee funds, nongame programs would be a likely target. Thus, without a comprehensive solution that included a means to provide greater license fee revenue, nongame programs stood to lose the most. By establishing an historical precedent whereby General Fund expenditures for nongame are authorized by statute, adequate funding for nongame programs are better assured. Funds now can be allocated in an incremental fashion by adding to or subtracting from the previous year's budget. There would be no further need for the Legislature to concoct a new funding plan for nongame each year and for nongame programs to compete with sports and commercial fishing programs for limited license fee revenues.

This strategy essentially places nongame programs on an equal footing with other General Fund programs. While it could be argued that an ideal plan may have been to devise a more specific revenue source, e.g., a special tax, 1978 was, in any case, an inappropriate time. The political mood in California favored cutting taxes, not adding to them. The designation of the General Fund as the source for nongame program support was, if nothing else, a promising alternative.

Impact of The Funding Legislation

The 1983–84 Governor's Budget (State of California 1983:R80), recently submitted to the California Legislature, succinctly summarizes the impact of AB 3416. It states, in part:

> Pursuant to Chapter 855, Statutes of 1978 (i.e., AB 3416), the General Fund is used exclusively for agreed upon nongame and environmental programs, and the Fish and Game Preservation Fund (i.e., the depository for hunting and fishing license fees) exclusively for game programs beginning in Fiscal Year 1979–80. This action and enabling legislation, which increased license fees indexed to inflation, has placed the Department on more secure financial grounds (parentheses added).

Perhaps the best overall indication of Department financial stability is the number of employee positions funded from sport fishing and hunting license fees. According to the Department, since the enactment of AB 3416, no layoffs of employees have been required. In fact, the number of Department employee positions funded from license fees has gradually increased (Carl Gzyms, pers. comm.).

Stability in the number of employees has been possible despite inflation, a steadily declining economy, and fluctuations in the revenues received from sources other than license fees and the General Fund (e.g., U.S. federal government funding for endangered species programs; reimbursements for projects conducted by the Department on behalf of other State agencies). That this was possible is due in large measure to the license indexing and cost apportionment provisions of AB 3416.

According to the Department, since the 1978 base year, fishing and hunting licenses have been raised by a cumulative inflationary index factor of 32.59 percent (Carl Gzyms, pers. comm.). This has meant that, for example, a resident sport fishing license that cost \$5.00 in 1977 cost \$6.75 in 1983; a resident fishing license and the stamps needed to take trout increased over the same period from \$10.00 to \$13.50; a deer hunting license and tag increased from \$13.00 to \$17.25. These increases have not resulted in any significant decrease in license buyer demand, as indicated by the fact that revenues have increased from \$24.4 million in 1977–78 to \$37.3 million in 1982–83 (State of California 1983).

The most graphic evidence of the success of the funding strategy is the Department's expenditures on nongame programs. Between FY 1978–79 and FY 1982–83 funding support for programs identified in the budget as nongame increased from approximately \$5.5 million to an estimated \$9.4 million (State of California, 1983). This represents nearly a 69 percent increase, or more than twice the 32.59 percent inflation rate for the same period.

One deficiency in AB 3416 was the fact that commercial fishing licenses and taxes were not indexed to inflation. As a consequence, commercial fishing programs will continue to face the same problems that were confronted by all Department programs prior to the passage of AB 3416: funding instability. Because of the AB 3416 policy requiring only commercial fishing revenues to support commercial fishing programs, funds can no longer be diverted from other revenue sources to support commercial programs. Some of these programs may eventually be eliminated unless commercial revenues are increased to match costs.

Conclusion

Two provisions of California's Department of Fish and Game funding strategy appear to have widespread applicability to other States that rely heavily on license fee revenues to support their fish and wildlife programs. California's favorable experience with indexing license fees helps to demonstrate that this mechanism can stabilize revenue flows during periods of high inflation and financial insecurity. Furthermore, funding nongame and environmental programs from the state's general fund, as suggested nearly a decade ago (Clement 1974), appears to be a viable alternative to special funding for these purposes. This entire approach has proven to be politically acceptable when the interest groups served by fish and wildlife agencies understand and agree to the basic concept of equitable cost apportionment.

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Wyoming's Wildlife Trust Fund

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Wyoming has the finest wildlife resource in the lower 48 states. Since the Wyoming Game and Fish Department escaped from legislative oversight in the 1930s, Wyoming's wildlife populations have reached their highest levels since statehood was granted. Now these trends are beginning to change.

The Wildlife Trust Fund is a way to meet these changes. Wyoming wildlife's current happy state of affairs is due to a combination of factors, including good management, large tracts of public land, recent favorable winters, habitat provided by private lands, a past history of low human population levels, and a moderate pace of development.

However, recent dramatic changes in our pace of development and population increase promise to impact the state's wildlife resource. Recent declines in moose (1975–1,688; 1980–1,413) and deer (1970–96,889; 1980–61,000) harvests show the beginning of a downward trend.

A hard winter could quickly reduce antelope and deer herds. Increasing pressures are affecting elk critical winter ranges, migration routes, and calving areas. Many quality fishing areas also are degrading.

Bold and innovative steps must be taken to insure the future of our wildlife. The key is habitat conservation. The Wildlife, Recreation and Conservation Trust Fund (known as the Wildlife Trust Fund) will accomplish that goal.

The Wildlife Trust Fund dedicates monies generated from the extraction of nonrenewable mineral resources to the maintenance and perpetuation of renewable wildlife and recreational resources. Compared with other funding options, a 1981 survey showed the following preferences: (1) Mineral taxes–55 percent; (2) General Fund appropriations–19 percent; (3) other taxes–13 percent; and (4) no additional funding from any source–2 percent.

Currently, Wyoming's wildlife conservation programs are supported by the sale of hunting and fishing licenses and by federal aid monies. Both these sources of income are relatively fixed and largely committed to the maintenance of existing conservation efforts. Support for these user-oriented efforts is a problem that can be addressed through existing revenue sources and through the sale of a conservation stamp.

In the short term, the Wildlife Trust Fund will bring relief to the Game and Fish Department's overburdened operating budget. It will replace monies currently coming from hunting and fishing license fees and going for EIS analyses, nongame conservation, fisheries improvement, and other habitat conservation measures. Given a recent (1980) license fee increase, the Game and Fish Department can expect to remain solvent through 1985.

Hunting and fishing alone contribute \$150–\$200 million annually to the state's economy, a return of \$10–\$15 for every dollar expended by the Game and Fish Department. Surveys indicate similarly high economic returns from nonconsumptive uses of wildlife such as tourism, photography, nature study, etc.

Wyomingites and visitors enjoy the highest hunting success rates of any state for almost all big game species (84%–antelope; 84%–moose; 56%–deer; 30%–elk; 50%–sheep). In 1980, Wyoming residents enjoyed 2.6 million hunting and fishing days, which represent about 5.5 days/person.

Wyoming has the world's largest elk herd; the greatest concentration of bighorn sheep in North America; the largest population of sage grouse in the U.S.; the world's largest shiras moose herd; the majority of pronghorn on the continent; most of the remaining grizzlies in the lower 48 states; and the only black-footed ferrets.

Wyoming could provide General Fund support for wildlife conservation during the mineral wealth boom years. But recent declines even in the state's minerals economy signal that the time is ripe for Wyoming to assert its responsibility for wildlife needs far into the future. If wildlife is to remain part of the state's heritage, we need a conservation program with longterm stability and dependability.

All Wildlife Trust Fund-related expenditures would require prior legislative approval. There are other examples of earmarked or permanent accounts—water development, the University of Wyoming, public schools, highways, etc.

In 1971, the Game and Fish Department reviewed 14 projects for their impact on wildlife resources. By 1980, this number had grown to 500. In a 1979 survey, 81 percent of Wyomingites favored finding alternative funding to study and mitigate impacts on nongame species. Currently $500,000/year of license money is spent on these activities. Though conflicts between wildlife and development are inevitable in some cases, adequate information on all wildlife resources can help arbitrate conflicts, mitigate impacts, avoid delays due to lack of information, and avoid federal involvement related to threatened and endangered species.

The bill currently (at this writing of February, 1983) before the Wyoming state legislature (it has passed the Senate 19–11 and awaits a House committee hearing) would provide fiscal support as illustrated in the accompanying diagram (Figure 1).

It would also supply, subject to legislative appropriation, recreation expenditures for:

1. Improvements to state parks and recreation facilities.
2. Acquisition of new state parks and recreational areas.
3. Acquisition of access to recreational sites and public lands.
4. Acquisition and improvement of scenic and historic sites.
5. Participation in water development projects.

Also subject to prior legislative approval, the Wildlife Trust Fund would authorize expenditures for these wildlife programs:

1. Maintenance of wildlife habitats.
2. Enhancement of wildlife habitats.
3. Acquisition by easement of wildlife habitats.
4. Expansion of wildlife programs to include Wyoming's entire wildlife resource.
5. Participation in water development projects.

The Wildlife Trust Fund also includes the following benefits and safeguards for agriculture, which to this point has been the main source of opposition to the concept:

1. Provides compensation for protection of critical habitats by keeping them in agricultural usage.
2. Provides increased Farm Loan potential.

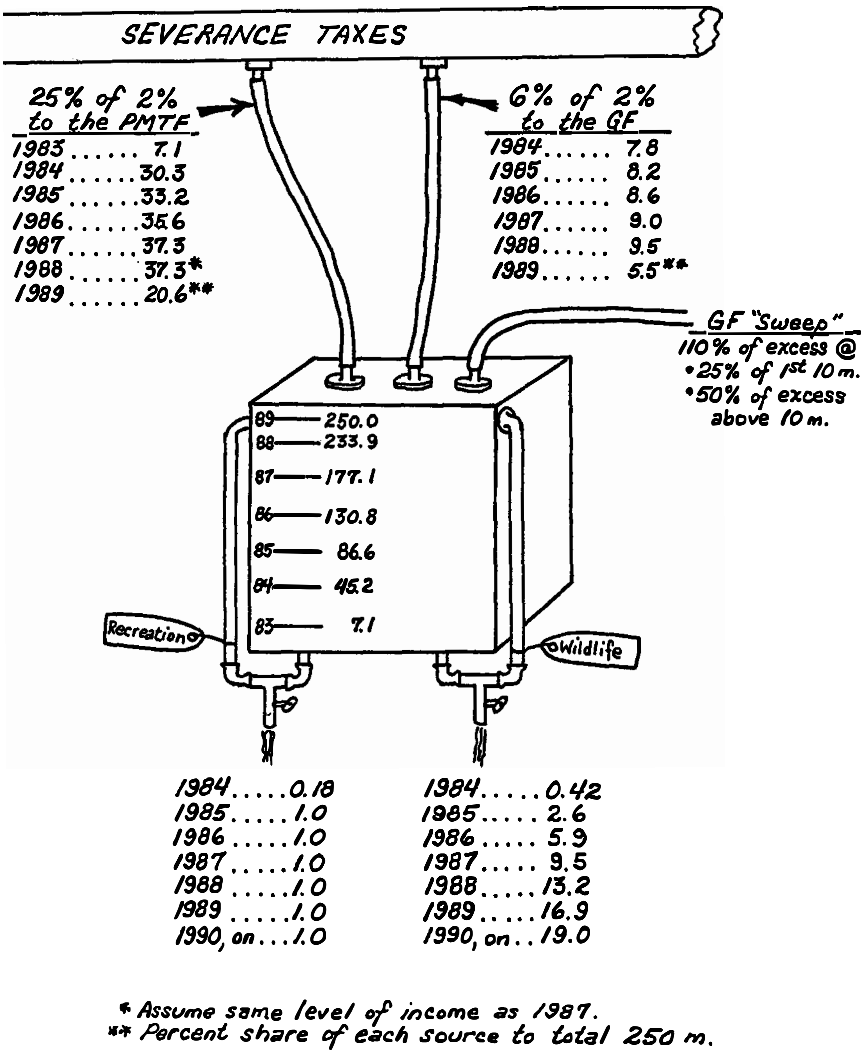

Figure 1. Funding mechanism for the wildlife trust fund.

3. Provides for wildlife and recreation to contribute to water storage.
4. Provides funds for facilities to relieve recreational pressure on private lands.
5. Acquisition of lands in fee title is prohibited.
6. Use of eminent domain expressly prohibited.
7. All expenditures must be appropriated by the legislature.
8. Habitat easements limited to big game, game birds, game fish, migratory game birds, protected birds, small game, and trophy animals.

Figure 1 illustrates the funding mechanism for the Wildlife Trust Fund. Input to the Fund comes from three different sources:

1. 25 percent of 2 percent of the annual money that goes to the Permanent Minerals Trust Fund (PMTF).
2. 6 percent of 2 percent of the annual money that goes to the General Fund (GF).
3. A formula for a General Fund "sweep" of excess revenues.

These combined revenue sources would yield $250-million by 1989. Though revenues from the Wildlife Trust Fund would go to both the Game and Fish Department and the Recreation Department, there is a cap of $1-million per year on recreation expenditures.

Environmental Contaminants and Wildlife

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Effects on Wildlife from Use of Endrin in Washington State Orchards

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Introduction

Endrin is a chlorinated hydrocarbon of the cyclodiene family; it is the common name for a technical pesticide that contains at least 92 percent of the endo-endo stereoisomer of dieldrin (Jager 1970). Endrin was introduced as an insecticide in 1951, and its efficacy as a rodenticide was discovered later. Since 1955, it has been used to control orchard mice (Petrella et al. 1975). The extreme toxicity of endrin was established in a wide variety of experimental animals (Treon et al. 1955, Hill et al. 1975, Grant 1976). The laboratory findings were borne out in the field where endrin use was associated with widespread mortality of organisms in aquatic and terrestrial systems (Dustman and Stickel 1966, Mount and Putnicki 1966, Mendelssohn 1972, Blus et al. 1979, Stickel et al. 1979b). Recent use of endrin has greatly decreased in the United States and other parts of the world (Sittig 1980) because of environmental concerns (Mrak 1969) and the development of resistance in certain pests (Webb and Horsfall 1967, Brown 1971). Endrin is still authorized as an orchard rodenticide in the United States, although its use in that capacity is prohibited in New York. In Washington State orchards, endrin is one of several rodenticides currently in use. One annual application of 1.2 to 1.5 pounds per acre (1.3 to 1.7 kg/ha) is sprayed in late fall. Mortality of wildlife from endrin use in Washington orchards has apparently occurred for several decades; endrin residues were detected in tissues (no brains analyzed) of about 20 birds found sick or dead from 1969 through 1979 (Washington Dep. of Game, pers. comm.). Wildlife mortality in orchards continued, and concern about endrin and several newer rodenticides, particularly the anticoagulant Ramik Brown® (diphacinone) led to our initiating the present study in Washington State to determine effects of rodenticides on wildlife. The objectives of this paper are to list residues of endrin that were detected in wildlife associated with orchards and to further define and measure the adverse effects induced by these residues, particularly in regard to mortality and depressed reproductive success. Findings regarding other rodenticides will be reported elsewhere.

Study Area and Methods

A study area was established in the vicinity of Wenatchee (central and north-central Washington) in October 1981; the study is scheduled to continue through October 1983. Results presented here include data collected through July 1982. The fruit orchards in this area are primarily located in valleys along streams or on terraces near the streams. The orchards are usually situated in rather narrow, somewhat discontinuous blocks that are interspersed among diversified habitat types that include the remnant riparian zone and extensive areas occupied by shrub-steppe and steppe. Talus slopes, cliffs, coulees, and canyons are also present in the vicinity. Apple orchards predominate in the area, but large acreages of pears and cherries also exist together with small acreages of other fruits such as apricots and peaches.

Carcasses of wildlife found dead in the orchards were brought to us by Washington Department of Game personnel or private citizens. We made no systematic carcass searches nor did we conduct systematic censuses of wildlife populations in orchard habitat because of restrictions on time and personnel. When the cause of death of specimens was not obvious, those that were in suitable condition were stored in a freezer until they were shipped to the U.S. Fish and Wildlife Service National Wildlife Health Laboratory in Madison, Wisconsin, for necropsy. Tissues for histological study were fixed in 10 percent formalin, embedded in paraffin, sectioned, and stained. The entire brain and other tissues were removed and placed in chemically cleaned glass bottles, and the carcass, except for skin, feet, wings, liver, kidney, and gastrointestinal tract, was wrapped in aluminum foil and refrozen.

We also analyzed tissues of some birds that apparently died from electrocution, gunshot wound, or impact with motor vehicles. Live, apparently healthy birds were also collected for residue analysis. California quail (see tables for scientific names) were either shot or trapped in or near Wenatchee from December 1981 to February 1982. Several recently-hatched quail were captured by hand in June 1982. Mallards and Canada geese were trapped and sacrificed in an orchard near Wenatchee in December 1981 and January 1982. A few other birds, several Nuttall's cottontails, and a number of montane voles were also collected. These specimens were frozen until examined later. Whole bodies of voles and young birds were analyzed; selected tissues were removed from the other specimens for analysis.

Wooden nest boxes were placed in or near orchards in the Wenatchee area in summer 1981. These 55 boxes were checked during the winter for roosting owls and other birds, and also during the nesting season to ascertain use by owls, American kestrels, and other cavity nesters. We also searched for natural nests of birds in the Wenatchee area. When a nest was located, a sample egg was collected for residue analysis. Some of the nests were marked and their fates determined by periodic visits. A nest was considered successful if one or more young fledged. Residues in the sample egg were then compared with nest success (Blus 1982). Starling clutches found in nest boxes were destroyed after collection of an egg. A few Canada goose eggs and dead young were collected by Washington Department of Game personnel during nest censuses in April; eggs were usually collected from inactive nests.

All samples were analyzed at the Patuxent Wildlife Research Center (Laurel, Maryland) for endrin and 14 other organochlorine pollutants, and some raptor and vole samples were analyzed for 12-ketoendrin. Homogenized samples were blended with sodium sulfate to remove moisture and then extracted seven hours with hexane in a Soxhlet apparatus. Lipids were removed from organochlorine compounds by Florisil column chromatography (Cromartie et al. 1975). Those samples analyzed for 12-ketoendrin required an additional Florisil elution with 12 cubic inches (200 ml) of 15 percent ethyl ether in hexane; this eluate required no additional column treatment. We separated the endrin and other organochlorine compounds in the first Florisil eluate by silica gel column chromatography using the procedure reported for pesticide elution from silicic acid (Kaiser et al. 1980).

We quantified samples by electron-capture gas-liquid chromatography using a 1.5/1.95% SP-2250/SP-2401 column. Recoveries of endrin, 12-ketoendrin, and other organochlorines from fortified mallard tissue ranged from 85 to 103 percent. Residue levels are not corrected for recovery values. The lower limit of reportable residues was either 0.1 or 0.01 ppm (μg/g) for endrin and 12-ketoendrin; residues are expressed on the basis of fresh wet weight. Residues in 9 percent of the samples were confirmed by gas chromatography-mass spectrometry. Other than brief mention of other organochlorines, we will consider only endrin and 12-ketoendrin in this paper because of the frequent occurrence and overwhelming effect of endrin.

Results

Mortality

Dead birds and a few large mammals were turned in by cooperators soon after the study was initiated in October 1981. Wildlife mortalities were reported each month, except May, through July 1982. The carcasses were separated into two categories depending on whether the cause of death was uncertain or was immediately obvious (gunshot, roadkills).

Incidences where cause of death was not immediately obvious involved 3 large mammals and 91 birds of 18 species. Most avian mortality (Table 1) occurred from November through March (79%); 20 deaths were reported in November and 19 in January. Dead California quail were reported from October through February and represented the largest total (25); they were followed by Canada geese (22 including 6 goslings) and chukars (9). Gallinaceous birds represented 37 percent of the dead

Table 1. Temporal distribution and relationship of endrin to mortality of 91 birds (18 species) that were found in or near Washington orchards, October 1981 to July 1982.

	Month											Number	
Species	O	N	D	J	F	M	A	M	J	J	Totals[a]	Brains analyzed	Deaths from endrin
California quail *(Callipepla californica)*	4	14	2	4	1						25	24	17
Canada goose-adults *(Branta canadensis)*		2		1[b]	6[b]	7[b]					16	13	0
Canada goose-goslings							6				6	0	[c]
Chukar *(Alectoris chukar)*			1	8							9	9	5
Barn owl *(Tyto alba)*			3	2	1				1		7	7	3
Cooper's hawk *(Accipiter cooperii)*			1	1			1			1	4	3	3
Northern goshawk *(Accipiter gentilis)*		1				2					3	3	2
Northern saw-whet owl *(Aegolius acadicus)*				1			1			1	3	3	0
Northern flicker *(Colaptes auratus)*		2	1								3	3	2
House sparrow *(Passer domesticus)*	2		1								3	1	0
Great blue heron *(Ardea herodias)*					1	1					2	2	0
Common loon *(Gavia immer)*				1	1						2	2	0
Sharp-shinned hawk *(Accipiter striatus)*		1			1						2	2	2

Table 1. (cont'd.)

Species	Month										Totals[a]	Number	
	O	N	D	J	F	M	A	M	J	J		Brains analyzed	Deaths from endrin
Red-tailed hawk *(Buteo jamaicensis)*										1	1	1	0
American kestrel *(Falco sparverius)*			1								1	1	0
Bald eagle *(Haliaeetus leucocephalus)*						1					1	1	0
Great horned owl *(Bubo virginianus)*			1								1	1	1
House finch *(Carpodacus mexicanus)*	1										1	1	1
Bohemian waxwing *(Bombycilla garrulus)*				1							1	1	0
Totals	7	20	11	19	11	11	8	0	1	3	91	78	36

[a]Excludes mortality from other obvious causes such as gunshot, roadkills, electrocution.
[b]One died from botulism in January; one probably died from lead poisoning in February; and five probably died from lead poisoning in March.
[c]Six goslings probably died from endrin, but brains not analyzed.

birds encountered, followed by raptors (25%), and Canada geese (24%). Mortality in orchards was also reported in the fall and winter of 1982–1983; these data will appear in a subsequent paper.

Endrin Residues

Birds found dead. Endrin toxicosis was the major cause of death of birds found in or near Washington State orchards from October 1981 through July 1982 (tables 1 and 2). Of the 78 brains of birds from this group that were analyzed, 36 (46%) had lethal levels of endrin (≥0.80 ppm), 3 (4%) had residues in the danger zone (0.60 to 0.79 ppm), and a number of others had elevated residues in their tissues. Residues in brains that constitute lethal or dangerous levels were established in experimental studies with birds that were given endrin-contaminated diets (Stickel et al. 1979b). The danger zone was described as encompassing residues that are dangerous and sometimes lethal. According to experimental studies, a few birds with brains that contained 0.5 ppm of endrin had enteritis that was probably caused by endrin and was related to their deaths. In our study, an American kestrel that died with 0.51 ppm in its brain exhibited enteritis in its jejunum; whereas, a barn owl with the same amount of endrin did not have enteritis. Endrin-induced mortality in the 78 birds ranged from 88 percent in Accipiters, 67 percent in gallinaceous birds, and 0 percent in Canada geese (Tables 1 and 2). On 25 November 1981, a cooperator in Wenatchee observed the spraying of endrin in the orchard next to her home. Later that day, she observed a number of California quail in convulsions and collected 13 dead birds from the covey. Analyses of their brains revealed that all died from endrin (Table 2). Dead birds in the covey included 12 immatures (5 males and 7 females) and 1 adult male. Two other instances of multiple endrin-induced deaths in orchards included 3 quail and 5 chukars.

Endrin residues in tissues and crop contents of most birds found dead were very high. Overall, 59 of 78 birds were carrying endrin residues. Maximum endrin residues (ppm) included liver, 16.0; carcass, 2.8; and crop contents, 16.0 (Table 2). Brains of two Accipiters that died with lethal levels of endrin contained no 12-ketoendrin. A preliminary investigation between December 1979 and April 1981 resulted in locating 10 birds that were found dead in Washington orchards; brains of 5 contained endrin residues that were lethal or were in the danger zone (Table 3). Some of the birds found dead from 1969 to 1979 in Washington orchards contained residues of endrin, but their brains were not analyzed (Washington Dep. of Game, pers. comm.).

Endrin residues were detected in tissues of 6 of 14 birds (Table 4) that died from seemingly obvious causes (gunshot, roadkill, electrocution, or predation). Residues were especially high in a red-tailed hawk that died apparently colliding with a vehicle, and a house sparrow that showed signs of predation. Residues in the liver or breast muscle of these two birds were as high as we found in several birds that died with lethal levels of endrin in their brains. Residues of 12-ketoendrin were not detected in tissues of the seven raptors in this group (Table 4).

Birds collected. A series of California quail and a few Canada geese, mallards, and other birds were collected to determine residue burdens in apparently healthy birds (Table 5). Sensitivity level (0.1 and 0.01 ppm) and tissue selection also had a decided influence on the likelihood of detecting residues. In general, the highest

Table 2. Endrin residues (ppm, fresh wet weight) in tissues and crop contents of birds found dead in Washington orchards, October 1981 to July 1982.

Species	Number brains analyzed	Residues in brains			
		ND	0.01–0.59	0.60–0.79 (danger zone)	≥0.80 (lethal)
California quail[a]	24	5	1	1	17
Canada goose[b] (adults)	13	4	9	0	0
Chukar[c]	9	2	0	2	5
Barn owl[d]	7	0	4	0	3
Northern saw-whet owl[e]	3	3	0	0	0
Northern flicker	3	1	0	0	2
Common loon[e]	2	2	0	0	0
Northern goshawk[f]	3	1	0	0	2
Cooper's hawk[g]	3	0	0	0	3
Sharp-shinned hawk[h]	2	0	0	0	2
Bald eagle[e]	1	1	0	0	0
American kestrel	1	0	1	0	0
Red-tailed hawk	1	0	1	0	0
Great horned owl	1	0	0	0	1
Great blue heron[e]	2	1	1	0	0
House finch	1	0	0	0	1
Bohemian waxwing	1	1	0	0	0
House sparrow	1	1	0	0	0
Totals	78	22	17	3	36

Endrin residues (ppm) in other samples (number positive):
[a]Livers—ND to 8.50 (5 of 6), carcasses—ND to 0.98 (7 of 8), crop contents—ND to 16.0 (6 of 7).
[b]Livers—2.80 to 3.30 (2 of 2), carcasses—ND to 2.80 (7 of 10).
[c]Liver—ND to 16.00 (4 of 5), breast muscle—1.00 (1 of 1), carcasses—ND to 2.30 (3 of 4), crop contents—ND to 15.00 (2 of 3).
[d]Carcass—0.90 (1 of 1).
[e]Carcass—ND (0 of 1).
[f]Carcass—0.80 (1 of 1).
[g]Leg muscle—0.05 (1 of 1).
[h]Breast muscle—0.17 (1 of 1).

residues were detected in fat and the lowest in breast muscle. Of 36 California quail collected, 15 (42%) contained detectable residues of endrin; almost one-half of these quail had only breast muscle analyzed at the higher level of sensitivity. Residues in some of the quail were very high with maxima (ppm) of 0.12 in breast muscle, 5.30 in liver, and 2.60 in fat. Three of five Canada geese analyzed contained endrin residues with maxima (ppm) of 0.09 in breast muscle, 0.38 in liver, and 2.30 in fat. Only 4 of 16 mallards contained endrin with none detected in breast muscle. One great horned owl and a ring-necked pheasant contained endrin (Table 5).

In a similar collection of 45 California quail in February and March 1982 from several widely separated Washington orchards, residues of endrin (sensitivity level 0.005 ppm) were detected in livers of 44 and in breast muscle of 13 birds (Washington Dep. Game, pers. comm.).

Mammals. Few large mammals were found dead in Washington orchards; the

Table 3. Endrin residues (ppm, fresh wet weight) in tissues of birds found dead in Washington orchards, December 1979 to July 1981.

Species	Number brains analyzed	Residues in brains ND	0.01–0.59	0.60–0.79 (danger zone)	≥0.80 (lethal)
California quail	4	1	0	1	2
Bald eagle[a]	1	0	1	0	0
Sharp-shinned hawk	1	0	0	0	1
Northern harrier *(Circus cyaneus)*	1	1	0	0	0
Great horned owl	1	1	0	0	0
Northern saw-whet owl	1	1	0	0	0
Mourning dove *(Zenaida macroura)*	1	0	0	0	1
Totals	10	4	1	1	4

[a]No endrin detected in carcass.

brain of one bobcat was analyzed and contained no residues of endrin (Table 6). No endrin was detected in livers of four Nuttall's cottontails that were collected in January from an orchard where endrin was not currently used. Residues of endrin in whole bodies of trapped montane voles ranged from none detected to 0.78 ppm. The voles with endrin residues were collected from an orchard where endrin was currently used. Residues of 12-ketoendrin in voles ranged from none detected to 0.05 ppm. This metabolite of endrin was detected only in voles.

Eggs and young birds. Residues of endrin were detected in 23 of 52 eggs from 10 species of birds that were collected in or near Washington orchards in 1982 and in a golden eagle egg collected in 1980 (Table 7). Endrin residues were detected in eggs of each species collected except the long-eared owl; six eggs (11%) contained ≥0.3 ppm. Lowered reproductive success occurred in experimental eastern screech-owls *(Otus asio)* given endrin-contaminated diets when residues reached or exceeded 0.3 ppm in their eggs (Fleming et al. 1982). Maximum residues in this study were found in Canada goose eggs that contained 1.67, 1.17, and 0.60 ppm. High residues of endrin (≥0.30 ppm) were also detected in eggs of the golden eagle, California quail, and ring-necked pheasant.

Residues in some of the eggs of birds lured to the nest boxes the first year may only reflect short-term exposure to contamination in the area. For example, we did not observe wintering female kestrels in the Wenatchee area during the winter of 1981–1982. The best series of nesting data involves raptors, but low levels of endrin (≤0.07 ppm) were detected in 4 of 13 sample eggs. Considering 12 nests of raptors (8 American kestrels, 2 red-tailed hawks, and 2 long-eared owls) with established fates, all were successful except for 1 kestrel nest and 1 long-eared owl nest.

Reproductive success of some Canada geese nesting on islands in the Columbia River seemed to be affected adversely by endrin; however, eggs were collected

Table 4. Endrin residues (ppm fresh wet weight) in tissues of birds found in or near Washington orchards that died from obvious causes or were found sick and sacrificed, October 1981 to April 1982.

Species	Sample[a]	Number of analyses	Residues			
			ND	0.01–0.59	0.60–0.79	≥0.80
Mallard	B	3	3	0	0	0
(Anas platyrhynchos)	BM	3	3	0	0	0
	L	2	0	2	0	0
California quail	B	1	1	0	0	0
	BM	2	2	0	0	0
	L	1	0	0	0	1
Great horned owl	BM	2	2	0	0	0
	L	2	2	0	0	0
Northern saw-whet owl	B	1	1	0	0	0
	BM	2	2	0	0	0
	L	2	2	0	0	0
Long-eared owl	BM	1	1	0	0	0
(Asio otus)	L	1	1	0	0	0
Barn Owl	BM	1	1	0	0	0
	L	1	1	0	0	0
Red-tailed hawk[b]	BM	1	0	0	0	1
	L	1	0	0	0	1
Cooper's hawk	B	1	0	1	0	0
	BM	1	0	1	0	0
	L	1	0	1	0	0
House sparrow[b]	BM	1	0	0	0	1

[a]B = brain, BM = breast muscle, L = liver.
[b]Additional endrin residues (received late) in brains: Red-tailed hawk—1.10 (lethal level) and house sparrow—0.77 (danger zone).

only after the fate of the nest was established. Of the five eggs collected from the Rocky Reach Pool, the three with the highest endrin residues (0.60 to 1.67 ppm) were collected from abandoned nests and the two with the lowest residues (≤0.17 ppm) were unhatched eggs from successful nests. The eight goose eggs collected from other sites contained low residues of endrin (≤0.08 ppm). Analysis of whole bodies of two of six goslings found dead in a nest (Rock Island Pool) revealed high levels of endrin (0.88 and 0.85 ppm) that may have been associated with nest failure.

Endrin residues were 0.03 and 0.07 ppm in sample eggs from two unsuccessful nests of California quail and 0.08 and 0.55 ppm in sample eggs from two successful nests. The highest residue in this series was found in an infertile egg. Residues of endrin in five recently-hatched quail were low (0.03 to 0.12 ppm); however, several were collected in orchards with no current use of endrin. Endrin residues in sample eggs of black-billed magpies were generally low, and six of seven nests with established fates were successful. The two sample eggs with the highest residues, 0.12 and 0.20 ppm, were from nests with unknown fates. Two other instances of

Table 5. Residues of endrin (ppm, fresh wet weight) in tissues of birds that were shot or trapped in Washington orchards, December 1981 to February 1982.

			Residues[b]		
Species	Period	Sample[a]	Number samples analyzed	Range	Number positive samples
California quail	Dec.	BM	21	ND–0.02	1
		L	7	ND–0.89	4
	Jan.–Feb.	BM	15	ND–0.12	7
		L	10	0.19–5.30	10
		F	1	2.60	1
Mallard	Dec.	BM	8	ND	0
		L	10	ND–0.05	2
		F	7	ND–0.50	4
	Jan.–Feb.	BM	8	ND	0
		L	5	ND	0
		F	2	ND–0.50	1
Canada goose	Dec.	BM	2	ND	0
	Jan.–Feb.	BM	3	0.09	3
		L	3	0.19–0.38	3
		F	1	2.30	1
Ring-necked pheasant	Dec.	BM	1	ND	0
(Phasianus colchicus)		L	1	0.14	1
Great horned owl	Dec.	BM	1	0.02	1

[a]BM = breast muscle, L = liver, F = fat.
[b]Additional endrin residues (received late) in fat: Dec.—quail, 0.13, 5.40, 5.30, 6.40, and 6.00 and goose, 0.95; Jan.—quail, 0.09 and geese, 0.95.

high endrin residues in eggs merit mention. The golden eagle egg was collected in 1980 after the nest failed; it contained 0.31 ppm of endrin. The ring-necked pheasant egg with 0.53 ppm of endrin was apparently rolled.

Other Residues

Residues of other organochlorine pollutants were detected in most samples; these residues, with a few exceptions, were very low and posed no identifiable threat to wildlife. The DDT group, primarily DDE, was detected in 75 percent of the samples, PCB's (polychlorinated biphenyls) in 15 percent, dieldrin in 10 percent, and the chlordane group (including heptachlor epoxide) in 3 percent.

Discussion

The extreme toxicity of endrin to estuarine and freshwater systems was established several decades ago (Mount and Putnicki 1966). In contrast, Stickel et al. (1979b) reported that die-offs of terrestrial wildlife from endrin were not well documented because of analytical problems and lack of knowledge about diagnostic residues. Endrin killed a wide spectrum of wildlife in our study area and both

Table 6. Endrin residues (ppm, fresh wet weight) in tissues of mammals[a] from Washington orchards, October 1981 to March 1982.

Species[b]	Period	Sample[c]	Number samples analyzed	Residues[d] Range	Residues[d] Number positive samples
Montane vole *(Microtus montanus)*	Oct.–Nov.	WB	3	ND (ND)	0 (0)
	Feb.	WB	8	ND–0.78 (ND–0.05)	7 (6)
Nuttall's cottontail *(Sylvilagus nuttalli)*	Jan.	L	4	ND	0
Bobcat *(Lynx rufus)*	Oct.	B	1	ND	0

[a]Tissues of a muskrat *(Ondatra zibethica)* and a striped skunk *(Spilogale putorius)* that were found dead in orchards were not analyzed because cause of death of the muskrat was diagnosed as pneumonia and because of concern about rabies in the skunk.
[b]Bobcat was found dead, cottontails were shot, and voles were trapped.
[c]WB = whole body, L = liver, B = brain.
[d]Data in parentheses refer to residues of 12-ketoendrin; only voles were analyzed for this metabolite.

Table 7. Endrin residues (ppm, fresh wet weight) in eggs of birds collected in or near orchards in Washington, 1980 and 1982[a].

Species	Residues[b] *n*	GM	95% CL	Range	% ≥ 0.3
Golden eagle *(Aquila chrysaetos)*	1(1)			0.31	100.0
California quail	6(5)	0.09	0.03–0.26	ND–0.55	17.0
Canada goose	13(6)			ND–1.67	23.1
Black-billed magpie *(Pica pica)*	8(3)			ND–0.20	0.0
Mallard	1(1)			0.01	0.0
Ring-necked pheasant	1(1)			0.53	100.0
European starling *(Sturnus vulgaris)*	10(3)			ND–0.23	0.0
American kestrel	8(3)			ND–0.07	0.0
Red-tailed hawk	3(1)			ND–0.06	0.0
Long-eared owl	2(0)			ND	0.0

[a]Eagle egg collected in 1980; remainder in 1982.
[b]*n* = sample size with number of samples positive for endrin in parenthesis, GM = geometric mean, 95% CL = 95% confidence limits.

acute and chronic toxicity occurred. The circumstances surrounding the deaths of 13 California quail in a Wenatchee orchard on 25 November 1981 provide convincing evidence of the extreme toxicity of endrin to the biota. All of the 13 quail died on the day of spraying; brains of all birds contained lethal levels of endrin and elevated residues were detected in their livers and carcasses. Food in the crops of four quail contained from 5.7 to 16.0 ppm or from 0.001 to 0.003 grain per pound of body weight (0.15 to 0.48 mg/kg). The amount of endrin in the crop contents was generally much lower than the LD_{50} for several gamebirds given capsule doses of endrin (Tucker and Crabtree 1970); whereas, the concentration in the food is near the LC_{50} of 14 ppm in northern bobwhites *(Colinus virginianus)* given endrin-contaminated diets for five days (Hill et al. 1975). The endrin residues in the crop contents are indicative of recent heavy exposure to endrin and its potential hazard to the birds; however, it does not provide quantification of actual hazard of endrin from previous ingestion of contaminated food or from dermal and respiratory routes (Reuber 1979). The extreme dermal toxicity is indicated by the current use of endrin on perches for the control of pest birds (Brown 1978). One of the major routes of exposure of orchard mice to endrin is through licking of their contaminated pelage after spraying. Birds such as California quail often frequent orchards during or shortly after spraying and preening of contaminated feathers probably provides additional exposure to endrin.

All experimental passerines died two to nine days after they were given a diet containing 10 ppm endrin; fat was greatly reduced or absent in all birds that died and pectoral musculature was reduced in some (Stickel et al. 1979b). In contrast, the pectoral musculature was not obviously reduced in any of the 13 California quail found dead in Wenatchee, and most still had good stores of coronary fat and body fat. Therefore, the evidence strongly suggests that the 13 California quail died from acute exposure to endrin. Acute toxicity from endrin was also probably related to mortality of the three quail that died on 25 October 1981 and the five chukars that died on 9 January 1982. In a similar occurrence near Monitor, Washington on 20 December 1972, 8 chukars were collected from a flock of 35 to 40 birds that were exhibiting erratic behavior. Residues of endrin were present in the liver and breast muscle of all 8 chukars; livers of 5 birds had very high levels (2.8 to 4.9 ppm) (Washington Dep. of Game, pers. comm.). Endrin is capable of inducing mortality within a short time after exposure; some laboratory rats died seven hours after dosage (Bedford et al. 1975b).

Chronic toxicity from endrin also occurred in Washington orchards. The single post-harvest application of endrin is generally completed in December. Most endrin-induced mortality occurred in the late fall and early winter; however, single birds died from endrin in March, April, and July. A Cooper's hawk that died after it fell from flight on 18 July 1982 had a lethal level of endrin in its brain. Mortality from endrin in such instances probably results from mobilization of residues from lipids as a result of stresses from food shortage, reproductive activities, weather, and other factors (de Freitas et al. 1969, Stickel and Rhodes 1970, Van Velzen et al. 1972). Endrin is capable of inducing serious physiological problems; telencephalic functions such as vision may be adversely affected in birds and mammals (Revzin 1966). Such problems may be related to mortality of animals exposed to endrin such as the red-tailed hawk that died after probable impact with a vehicle and the house sparrow that was apparently killed by a predator.

Direct endrin contamination of the simple food chains of quail and other species results in secondary poisoning when these animals are consumed by predators or scavengers. Effects of organochlorine pesticides on birds have been most devastating to those at the top of food chains involving fish or birds (Stickel 1975). A large number of Accipiters (goshawk, Cooper's hawk, sharp-shinned hawk) were found dead in orchards from April 1981 to July 1982. Causes of death of the 12 birds included endrin (8), gunshot (2), and unknown (2). Concerning owls, nearly all of the barn owls and great horned owls found dead contained residues of endrin, and several contained lethal levels; whereas, the saw-whet owls analyzed carried no detectable residues in their tissues.

The chances of detecting pesticide-induced mortality of wild birds or other animals are usually rather low even when intensive searches are conducted (Rosene and Lay 1963). Therefore, it seems reasonable to conclude that the verified mortality of wildlife from endrin in Washington orchards represents only a very small fraction of the total. There are few data regarding recent population trends of wildlife associated with orchards in Washington State. The orchard system around Wenatchee has a wide diversity of avian habitat. This system and surrounding areas support a relatively diversified avifauna; this may partially explain the extensive endrin mortality that occurs in Washington orchards. Most of the Accipiters are wintering birds attracted to a relatively abundant prey base. The precise source of these hawks is unknown, but they probably originate from a large area. We suspect that a large number of Accipiters are dying from endrin in Washington orchards; some adverse effects on reproductive success are also likely.

The occurrence of endrin residues in most collected birds and mammals from Washington orchards indicates an almost universal contamination of the system. In New York, the application rate of endrin to orchards was essentially the same as that in Washington orchards. Residues in New York orchards were very high at five months post-spray in surface soil, vegetation, humus, and voles. Detectable residues of endrin were still present in the same types of orchard samples one year post-spray (Mungari 1978). One of the characteristics of endrin that supposedly decreases its hazard is the low persistence in the environment in comparison with most of the organochlorine pesticides. Endrin is one of the least persistent organochlorines in mammals (Cole et al. 1970, Brooks 1974). The half-life of endrin residues in experimental mallards given a large dietary dosage (20 ppm) was only 3 days and 90 percent of the residues were lost after 33 days (Heinz and Johnson 1979); whereas, the half-life in tissues of birds fed rations containing low levels of endrin (0.05 to 0.45 ppm in combination with other organochlorines) ranged from 3 to 15 weeks (Cummings et al. 1967).

Wildlife occupying orchards may be exposed to very high concentrations of endrin. Although birds and mammals may lose their residue burdens rapidly, those occupying endrin-contaminated orchards may accumulate significant additional residues of endrin from food for months after spraying. Canada geese commonly feed in orchards located along the banks of the Columbia River, chukars sometimes feed in upland orchards, and quail feed in upland and shoreline orchards. Endrin is not universally used in Washington orchards; other rodenticides including several anticoagulants are widely used and zinc phosphide is utilized on a small acreage. Use of such materials undoubtedly reduces the hazard to wildlife from endrin.

Endrin metabolism and excretion in birds and mammals are somewhat unique among the chlorinated hydrocarbons. Endrin may be conjugated in the intestine such that the parent compound is excreted. This provides an apparent exception to the rule that lipophilic compounds are not excreted to a significant degree before metabolism (Bedford et al. 1975a, Matthews 1979). In addition, the efficient excretion of endrin in comparison to dieldrin is primarily related to its more rapid biliary excretion (Cole et al. 1970). Metabolism of endrin differs greatly among animal species. In laboratory rats given endrin, most that died contained low endrin residues in the brain; residues of the more toxic metabolite, 12-ketoendrin, predominated in the brain and apparently induced death (Bedford et al. 1975b, Hutson et al. 1975, Stickel et al. 1979a). In other experimental studies where birds and mammals were given endrin, 12-ketoendrin was found in small quantities in the brains and other tissues of mammals. When mortality occurred in these studies, it was related to residues of the parent compound in the brain (Bedford et al. 1975b, Baldwin et al. 1976, Stickel et al. 1979a, Stickel et al. 1979b). The other important metabolite of endrin, *anti*-12-hydroxyendrin, and the less important metabolites, *syn*-12-hydroxyendrin and several others, are generally more toxic than endrin but are readily excreted (Bedford et al. 1975b, Hutson et al. 1975, Baldwin et al. 1976). Thus, endrin is distinct among organochlorines in that all of its metabolites tested are more toxic and most are less readily stored than the parent compound. In our study, 12-ketoendrin was detected only in montane voles; tissues of owls and hawks contained no residues of this metabolite. Residues of 12-ketoendrin have not been detected in other studies involving experimental or wild birds (Baldwin et al. 1976, Mungari 1978, Stickel et al. 1979a). In New York orchards, residues of 12-ketoendrin were detected in soil, vegetation, invertebrates, and several species of mammals, including an opossum *(Didelphis marsupialis)* found dead with 0.14 ppm 12-ketoendrin and 0.04 ppm of endrin in its brain. The 12-ketoendrin in the opossum was similar to the concentration in brains of laboratory rats that apparently died from this ketone (Mungari 1978).

Endrin residues exceeding 0.3 ppm in sample eggs from the Wenatchee area were associated with nest failures in four of five instances. The association between nest failure and endrin residues in eggs in Washington seems to parallel the experimental study with eastern screech-owls where residues of ≥0.30 ppm in sample eggs were associated with lowered reproductive success (Fleming et al. 1982). In a study of brown pelicans *(Pelecanus occidentalis)* in Louisiana, reproductive failure occurred when endrin residues in eggs averaged 0.5 ppm (Blus et al. 1979). Low residues of endrin (≤0.05 ppm) were detected in three pooled samples of eggs of three passerine species nesting in New York orchards (Mungari 1978). Endrin seems to be affecting adversely reproductive success of some birds that are associated with Washington orchards; however, sample sizes are small and additional study is required to determine the extent of the problem.

In Washington orchards, endrin is entering the environment and food chains in quantities that are sufficient to induce widespread mortality and probable sublethal effects, including lowered reproductive success. Recent research in Virginia demonstrated excellent control of pine voles and meadow voles *(Microtus pennsylvanicus)* with several anticoagulants and zinc phosphide pellets (Byers et al. 1982). Although several of these rodenticides may induce adverse effects on wildlife (Evans and Ward 1967, Savarie et al. 1979, Mendenhall and Pank 1980), it seems clear that problems associated with use of these alternatives are much less serious (Hood 1972, Kaukeinen 1982) than the hazard presented by endrin.

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Impacts of Forest Herbicides on Wildlife: Toxicity and Habitat Alteration

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Introduction

Of the contaminants introduced into the environment of an animal, herbicides are unique in simultaneously causing two classes of potential responses—toxic and habitat. Herbicides that are used to poison plants have the potential for effects on wildlife through toxicity and/or habitat alteration. A complicating factor in the use of herbicides is the nature of the chemicals themselves—certain herbicides (e.g., 2,4,5-T) contain contaminants that are toxic to animals, but are unrelated to the prescribed effects of the herbicide itself. These contaminants form the basis for much of the public concern over the use of herbicides.

This paper begins with a review of both laboratory and field studies on the possible direct toxic effects of herbicides on terrestrial vertebrates, primarily birds and mammals. Alteration of the palatability of forage and changes in reproductive success are also discussed. Emphasis is placed on the use of herbicides in forestry; studies dealing with agricultural systems are referenced where appropriate. The indirect effects of herbicides on wildlife-habitat are then conceptualized and quantified using data from a 3-year study on effects of phenoxy and glyphosate herbicides on bird and small mammal communities in western Oregon. Data on density and habitat use are presented and compared with data available from other geographic regions.

Toxicity

Herbicides are used in forestry for a number of vegetation control purposes. 2,4-D is the most commonly used herbicide in forestry; the U.S. Forest Service used about 200,000 lbs (90,000 kg) of 2,4-D in fiscal year 1980 (Norris 1981a). The use of 2,4,5-T has declined over the past decade, with under 7,000 lbs (3,175 kg) used by the Forest Service in 1978 (Norris 1981b). According to Norris (1981b), techniques of herbicide application in forestry in a decreasing order of occurrence are: (1) aerial application of liquids by helicopter; (2) ground application of liquids by mist blowers; and (3) injection or basal applications of liquids into or on individual tree stems. Formulations used and methods of application are dependent upon specific management goals for the area under consideration. Much of the public concern over the use of herbicides involves aerial application. When objections are raised to the use of herbicides, the perception of the general public seems to apply to all herbicides for they usually think of herbicides as a single chemical rather than as a diverse group with widely varying characteristics (Witt 1978). Although beyond the scope of this paper, it is important to remember that herbicides used in forestry fall into numerous chemical classifications (e.g., nitro phenols, phenoxies, benzoics, pyridines, triazines, organic arsenicals); the chemical properties and modes of action of these herbicides are reviewed elsewhere (e.g., Witt 1978, Weed Science Society of America 1979).

By definition, herbicides are designed for plant control. In contrast to insecticides (e.g., DDT), herbicides are short-lived in the environment. Although the retention of residues varies depending on the specific chemical used, environmental conditions, vegetation density, and soil properties, herbicides degrade within days or weeks, rather than in months or years common to many other classes of pesticides. More specifically, once applied, herbicide residues are subject to degradation through volatilization, adsorption, leaching, plant uptake, and numerous chemical and biological processes (Norris 1981b). As capsulized by Newton and Norris (1976), the half-life of most herbicides in vegetation ranges up to 30 days. According to Norris (1981b: Table 4), residues of phenoxy herbicides remaining in vegetation one year after application are usually below 0.5 mg/kg.

The forest floor, rather than vegetation, is often the major receptor of aerially applied herbicides, either during initial application or via washing of foliage by precipitation. Norris et al. (1977) noted a slight increase in the amount of 2,4,5-T in forest floor litter between the time of application and one month post-treatment; this increase was attributed to the washing action of rain. Norris et al. (1978 in Norris 1981b) found that about 34 mg/m^2 of 2,4,5-T was washed into the forest floor from vegetation during the first 8 months after treatment with 2.24 kg/ha 2,4,5-T; 80 percent of the transfer occurred within 20 days of application.

Amitrole, 2,4-D, and 2,4,5-T are rapidly degraded in litter material (Norris 1971). Norris (1970) found that 80 percent of the amitrole and 94 percent of the 2,4-D were degraded in 35 days; 87 percent of the 2,4,5-T degraded in 120 days (see also Norris 1966). Glyphosate, a relative newcomer to forestry applications, degraded rapidly depending on soil type; about 17 to 45 percent of this chemical degraded in 28 days (Sprinkle et al. 1975). Norris et al. (1977) found that one year after application of 2,4,5-T (at 2.24 kg/ha), residue levels in forest floor material were less than 1 percent of the amount of herbicide initially applied. Numerous other studies on the persistence of herbicides were summarized by Norris (1981b).

The mere presence of a contaminant, however, does not imply that a toxic effect must follow for either target or nontarget organisms. As aptly summarized by Norris (1971): "An adequate evaluation of the hazard associated with the use of any chemical requires consideration of both the toxicity of the material and the potential for exposure of nontarget organisms. The hazard can be high only if both the toxicity of the chemical and the potential for exposure to a significant dose are high."

What then, is the relationship between residues of herbicides present in the environment and susceptibility of wildlife to acute or chronic poisoning? Naturally, this relationship varies among organisms and among chemicals and is further influenced by the physical condition of the animal. The extensive data on toxicity of herbicides to wildlife reveal that both acute and chronic doses are well above levels found in the environment under normal field application rates. Furthermore, chronic doses are difficult to realize because of the low persistence of herbicides (see reviews by Rowe and Hymas 1954, Rudd 1954, Springer 1955, Roberts and Rogers 1957, Way 1969, Heath et al. 1972, Kenaga 1975, Weed Science Society of America 1979, Norris 1981b). For example, Heath et al. (1972) experimentally tested about 20 herbicides on four species of birds. They clearly showed that the LC_{50} for most herbicides is high (usually >5,000 ppm for amitrole, atrazine, 2,4-D, 2,4,5-T, and picloram). By comparison, the LC_{50} of endrin (an organochlorine insecticide) was <22 ppm, and that of DDT (also an organochlorine insecticide) ranged from 311 to 1369 ppm depending on the species tested.

Most animals are physically unable to consume enough food in a short enough period of time to accumulate significant residues of herbicides at field application rates (e.g., Bjorn and Northern 1948, Roberts and Rogers 1957, Newton and Norris 1968). In addition, herbicide residues consumed orally are excreted rapidly by the body, a physiological process that is in marked contrast to the well-known bioaccumulation of many contaminants. Bioaccumulation is most likely to occur when organisms are exposed to persistent chemicals of low water solubility and high lipid solubility—herbicides do not generally meet these requirements and thus contrast strongly with many other pesticides (Norris 1981b). The data on bioaccumulation of phenoxy herbicides were reviewed by Norris (1981b). Norris concluded that, in general, more than 90 percent of pheonxy herbicides ingested is excreted unchanged in urine within 72 hours. Newton and Norris (1968) found that even with continued exposure to atrazine, 2,4-D, and 2,4,5-T in the field, black-tailed deer *(Odocoileus hemionus columbianus)* did not accumulate residues of these chemicals. Although residues of 2,4-D were present one day after spraying (at 4.48 kg/ha) in Florida common gallinules *(Gallinula chloropus),* Schultz and Whitney (1974) could find no detectable residues four days after spraying.

The reproductive performance of some animals has been adversely affected by certain pesticides (e.g., Peakall 1970, 1975, Cooke 1973, Blus et al. 1974). The high tolerance of animals to herbicide residues and lack of significant accumulation of residues in animals or their environment indicates that reproductive success should not be *directly* affected by herbicide application—numerous studies have shown this to be the case (see review by Kenaga 1975) in both field (e.g., Schultz and Whitney 1974, Schroeder and Sturges 1975) and laboratory (e.g., Kopischke 1972, Somers et al. 1974a, 1974b, Batt et al. 1980) experiments.

Concern has been raised over the chemical impurity 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD or dioxin) that is found in 2,4,5-T. The numerous and often controversial studies that explored toxic properties of 2,4,5-T containing dioxin were reviewed by Cranmer (1978) and Norris (1981b). While TCDD is very toxic at high doses (e.g., 25 ppm), the current level of TCDD found in 2,4,5-T is usually <0.1 ppm according to Kenaga (1975) and Cranmer (1978). These authors concluded that the use of 2,4,5-T containing current levels of impurity of TCDD presents little chance of acute or chronic toxicity effects. Crosby and Wong (1977) found that most TCDD in current herbicide formulations, when applied to leaves or soil and exposed to sunlight, disappeared in under six hours due to photochemical dechlorination. Norris (1981b) reviewed the extensive literature on bioaccumulation of TCDD and concluded that substantial bioaccumulation of TCDD does not occur in animals in or near areas treated with 2,4,5-T in operational programs. While concern over the toxicity of TCDD is warranted, we should focus our concern on these (or other) impurities and not on herbicides in general. Dioxins are also released into the environment from sources other than 2,4,5-T (e.g., industrial chemicals) (Cranmer 1978).

Food Preferences

A class of responses by wildlife to herbicides that is associated with both toxicity and habitat alteration is food preference and palatability. Rowe and Hymas (1954), Springer (1955), and Campbell et al. (1981) reviewed the repellent properties of herbicides to wildlife. In a field test, Newton and Norris (1968) found that black-tailed deer did not leave areas sprayed with atrazine or 2,4,5-T. While Sullivan and Sullivan (1979) could not show that spraying with glyphosate affected the feeding preferences of blacktails, Campbell et al. (1981) noted reduced acceptance by blacktails of seedling Douglas-fir *(Pseudotsuga menziesii)* treated with glyphosate. Campbell et al. found that glyphosate was phytotoxic, which indicated possible deer sensitivity to either the herbicide or a physiological change of the seedlings. They did not, however, find a significant reduction in deer browsing using 2,4-D, 2,4,5-T, atrazine, dalapon, or fosamine. Fink (1974 in Kenaga 1975) showed that bobwhite *(Colinus virginianus)* fed a mixture containing 2,4,5-T did not reduce food consumption until >2,000 ppm was attained. As summarized by Ware (1980): "Though low levels of phytotoxic residues have persisted from one season to the next, data from many sources indicate that accumulation of massive levels of selective herbicides is unlikely."

Habitat Relationships

Animal ecologists have long known that a primary factor governing the distribution and abundance of wildlife is the structure and composition of vegetation. The richness and diversity of animal communities can often be related directly to the vertical and/or horizontal diversity of vegetation. One would intuitively anticipate, then, that changes in plant communities would be followed by changes in the associated animal communities. To establish the relationships between herbicide-induced vegetation changes and changes in animal communities, we must first determine what "habitat" means for each species. Then, we must determine how herbicides affect this habitat. Finally, the response of wildlife to changes in their habitat must be assessed. Given that animals have been classified according to their use of habitats along a continuum running from "specialist" to "generalist," a continuum of responses can be expected.

In this section we review studies on the effects of herbicide-induced habitat changes on birds and mammals. Herbicides usually are used in forestry in an attempt to shorten the brush-stage of succession and hasten the conversion of a site into one dominated by the desired species, usually conifers. Total removal of plants competing with conifers is not desired. Rather, the goal is suppression of competing vegetation for a time sufficient to allow conifers to gain dominance. The developing conifers can then physically shade much of the competing vegetation.

Birds

Herbicides are often used to reduce brush cover and increase forage production for domestic livestock on rangeland. Wildlife associated with such areas are, of course, susceptible to treatment effects during such practices. For example, Best (1972) found that, in sagebrush *(Artemisia tridentata)* habitats treated with 2,4-D, numbers of nesting Brewer's sparrows *(Spizella breweri)* declined 54 percent after sagebrush was killed by treatment. Numbers of ground nesting vesper sparrows *(Pooecetes gramineus)* remained unchanged, however. In addition, major plant and animal foods used by the birds differed in amount (not variety) after treatment. When only 50 percent of the sagebrush plants were killed, however, Best found numbers of neither species of birds reduced. Best's study, however, only concerned one year post-spray effects. Schroeder and Sturges (1975) examined nesting Brewer's sparrows one and two years after sagebrush was treated with 2,4-D. They found that one year post-spray, dead leaves remaining on plants apparently provided sufficient cover for use as nesting sites. By two years post-spray, density of nesting sparrows was reduced 99 percent on treated plots due apparently to dropping of leaves from dead plants—all Brewer's sparrows seen in sprayed plots were near areas of live sagebrush that survived treatment.

A series of studies (Beaver 1976, Savidge 1977, 1978, Osaki 1979) were conducted in a *Ceanothus*-manzanita *(Arctostaphylos patula)* brush field in the Sierra Nevada treated with 2,4,5-T. Beaver (1976) analyzed bird populations one and two years after treatment. Although no effect of herbicide treatment was noted on avian species composition or abundance after treatment, Beaver did not compare quantitatively his post-spray data with that of an unsprayed control. Inspection of his data actually reveals a decline in the density of breeding birds one and two years post-spray. Savidge (1977, 1978) used one of the study areas used by Beaver (1976) in a comparison of six year post-spray effects. Savidge found that the total number of birds in the unsprayed plot was twice that of the sprayed plot. She concluded that the collapsing of dead *Ceanothus* and manzanita was responsible for the marked difference in nesting density. She also suggested that the presence of dead but standing plants that were present during Beaver's (1976) study was responsible for the latter's conclusion of no treatment effects. It should be noted, however, that Savidge's study design was unreplicated, and conifers on the treated plot had been lightly thinned one year prior to her study. Osaki (1979) sampled from the same general area as Beaver (1976) but at six to seven years post-spray. Osaki found a significantly lower total live plant cover on treated plots relative to untreated plots. Total abundance of birds was nearly identical between treated and untreated plots. However, certain species had higher densities on treated plots (e.g., green-tailed towhee, *Chlorura chlorura*), while others had lower densities on treated plots (e.g., yellow warbler, *Dendroica petechia*).

In Norway, spraying of deciduous scrub by 2,4,5-T was followed by a 30-percent reduction in the number of birds the following year, and the number of birds remained low on sprayed areas five years after treatment (Slagsvold 1977). Slagsvold suggested that a major factor in the reduced numbers for most species after spraying was a reduction in the availability of food.

Much of the aforementioned studies relied solely on changes in density to infer treatment effects. There are, however, numerous factors which can influence birds that are independent of treatment (e.g., overwinter mortality, pre-existing differences in site vegetation between treated and untreated sites, abiotic factors). To strengthen the link between herbicide-vegetation and wildlife-vegetation relationships, we (Morrison 1982, Morrison and Meslow in prep.) designed a study that directly related changes in density of birds to changes in habitat use or foraging behavior. Using early-growth clearcuts in western Oregon that had received phenoxy herbicide treatment one or four years previously, we found only minor effects of herbicide treatment on vegetation one year post spray; most plants showed no signs of treatment four years post-spray. Spraying did, however, effectively eliminate the only major deciduous trees on the sites, red alder*(Alnus rubra)*. Removal of red alder reduced both vertical diversity and horizontal patchiness of vegetation on treated sites through at least four years post spray. Concomitant with changes in site vegetation were changes in foraging behavior of several species: birds using deciduous trees (e.g., Wilson's warbler, *Wilsonia pusilla*) were shown to increase use of shrubs on treated sites; densities for these species were lower on treated sites relative to untreated sites. Conversely, species utilizing shrub habitats were barely affected by spraying, especially after shrubs recovered from initial defoliation.

We (Morrison 1982: Appendix, Morrison and Meslow in prep.) also studied effects of glyphosate on bird communities. About 23 percent total plant cover was initially damaged by an operational treatment; deciduous trees were not damaged severely. By two years post-spray, vegetation on the treated site had nearly returned to pre-spray conditions. Virtually no difference in total density of nesting birds was evident between the treated and untreated site. Several species decreased use of shrub cover and increased use of deciduous trees one year after treatment. By two years post-spray, most species had returned to pre-spray use of vegetation. These changes in vegetation caused temporary increases (e.g., white-crowned sparrow, *Zonotrichia leucophrys*) and decreases (e.g., MacGillivray's warbler, *Oporornis tolmiei*) by birds on the treated site.

Mammals

A number of studies have investigated effects of herbicide application (especially 2,4-D) on pocket gophers (*Thomomys* sp.). The concern with pocket gophers was based on the apparent damage done to range and forest lands by this species. Keith et al. (1959), Tietjen et al. (1967), and Hull (1971) found that application of 2,4-D reduced forb cover, which allowed an increase in grass cover; this change in habitat significantly reduced the abundance of pocket gophers on their study sites. Over a 10-year period, Hull (1971) showed that spraying reduced pocket gopher abundance by over 90 percent. Crouch (1979) found that treatment of shrub and herbaceous cover with atrazine removed the food supply of pocket gophers, and as a result, caused a significant reduction in moundbuilding. Pocket gopher populations remained reduced for at least 10 years after treatment.

Johnson (1964) found that 2,4-D treatment of rangeland altered food availability for several species of rodents. For example, deer mice *(Peromyscus maniculatus)* increased consumption of grass seeds and decreased use of forbs and shrubs after 2,4-D reduced cover of the latter and allowed an increased cover of the former. Johnson also showed an increased abundance of montane voles *(Microtus montanus)* on treated sites with increased grass cover. In contrast, Borrecco et al. (1979) studied the effects of a herbicide-induced (atrazine and 2,4-D) reduction in grassy habitats on rodent populations. They found that effective control of herbaceous vegetation altered the species composition of rodent communities as they responded according to their species-specific habitat preferences. Species preferring grassy habitats were less abundant on treated than untreated plots. Savidge (1977, 1978) found that treatment of *Ceanothus* with 2,4,5-T caused increased numbers of yellow pine chipmunks *(Eutamias amoenus)* and golden-mantled ground squirrels *(Spermophilus lateralis)* on treated plots. She attributed this difference to resistance of currant *(Ribes)* to spray treatment and the more open habitat created by reduction in *Ceanothus* cover. Anthony and Morrison (in prep.) analyzed effects of glyphosate on small mammals in western Oregon one and two years after treatment. They found that glyphosate treatment reduced shrub cover, which caused a temporary (one year) increase in grass and forb cover under damaged vegetation. Abundance of Oregon voles *(Microtus oregoni)* increased on treated sites one year post spray in response to these habitat changes, but returned to near pre-spray levels two years post-spray. Numbers of other rodent species were not markedly affected by treatment.

Most studies dealing with the influence of herbicide application on big-game involved analysis of the effects of herbicides on deer browse. Most studies have found that preferred species of browse can be increased if herbicide application is carefully planned (e.g., Krefting et al. 1960, Coulter 1957, Mueggler 1966, Krefting and Hansen 1969, Borrecco et al. 1972, Bramble and Byrnes 1972). These results are not universal, however. Lyon and Mueggler (1968) showed that the preferred browse species can be quite susceptible to treatment, and that many favorable effects of treatment for browse improvement can be of very short duration.

Concluding Remarks

We have seen that while residues of herbicides can be detected in the environment, these residues are of low concentration and short-lived. Further, while residues are sometimes detected in wildlife, levels in tissues are low and do not accumulate. Thus while the link between herbicides and their toxic effects on wildlife has been established, this link is simply not capable of passing significant effects on to wildlife if recommended application procedures are followed—the only exception being localized cases of possible phytotoxicity that influence diet preference.

Our review indicates that the response of wildlife to herbicide-induced habitat change is extremely varied. Variations in response by wildlife are understandable given that plants respond in a species-specific manner to the chemical applied, the rate and time of application, and various environmental constraints. What generalizations can be drawn then? First, we have seen that certain animals respond to habitat alteration by increasing their use of undamaged vegetation. Other species, however, are seemingly unable to compensate for habitat loss and thus decline in density. Other species respond to habitat change by increasing in density. This shift in concentration of density is due, quite simply, to changes in the amount of preferred habitat available to each species following treatment. An increase in density by certain species following treatment is not necessarily desired, for this change has been artificially induced by a management practice. Increasing deer browse through herbicide application, for example, would also cause a decreased habitat availability for other species.

The general response of wildlife to herbicide application can thus be predicted *if* data are available on the range of habitats occupied by a species and their density in these habitats. Changes anticipated in animal communities can be alleviated, in part, by careful planning of treatment. What is generally deemed desirable is retention of the natural variety of vegetation types so that managed lands can supply a diversity of vegetation and wildlife through time. The goal of most forest management systems, however, is conversion to, and then maintenance of, a conifer dominated stand. Of course, various laws and directives (e.g., National Forest Management Act of 1976) require maintenance of viable populations of native wildlife (i.e., diversity). As we found in western Oregon (Morrison 1982, Morrison and Meslow in prep.), retention of even small patches of deciduous trees will maintain a similar bird community between treated and untreated sites. Deciduous trees and shrubs can usually be retained in areas of unstable soil, along logging roads, and as stream buffer strips, without severely impacting the economic return from an area. Much of the brushy vegetation removed by herbicide treatment also plays a role in nutrient cycling and soil stability.

Other methods are available for converting areas to conifers. For example, mechanical removal (both mechanized and by hand) of competing vegetation is possible. Hand thinning of both conifers and deciduous trees that survived herbicide treatment is a standard practice in many silvicultural systems (e.g., precommercial and commercial thinnings). Although the economic and social rationale (e.g., supplying jobs) for mechanical versus chemical treatment is beyond the scope of this paper, the salient point is that both methods alter wildlife habitat because, if successful, they both achieve the same end point—domination of an area by a desired commercial species. As aforementioned, the major consideration for wildlife is careful planning of treatment. We must remember, however, that the important decision is made when land is put under management for optimization of timber growth. The initial impact of clearcutting, for example, has a far greater influence on wildlife than does any follow-up treatment. Concerned parties must consider the response of wildlife to the entire range of silvicultural treatments and not become obsessed with a single aspect of that treatment. Likewise, management agencies must embrace the spirit of the law and honestly provide a variety of habitat types for native wildlife. Failure to meet such directives may invoke further regulation.

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Organochlorine Pesticides and PCB's: A Continuing Problem for the 1980s

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Introduction

Levels of organochlorine pesticides and PCB's (collectively referred to as OC's) have decreased dramatically in the environment during the last decade. These improvements have led to a healthier prognosis for DDE sensitive species. However, concentrations of OC's, arising both from historical and current use, remain sufficiently high to reduce recruitment and survival in selected wildlife populations.

Our objective is to bring about an awareness that OC pesticides and PCB's continue to present significant environmental challenges to North American fauna in the 1980s. To meet this end, we will first discuss trends in OC residues in wildlife as indicated by the National Pesticide Monitoring Program (NPMP). Next, we will support our contentions about continued exposure of wildlife to OC's by presenting problems related to recent use, then problems related to historical sources, and finally, problems related to unidentified sources of OC's. Then we will mention current findings of OC's in predatory birds. We present the predatory bird data separately because of the vulnerability and sensitivity of these species to OC's. Our summary and conclusions will follow.

To present the most current information, we have relied heavily on unpublished manuscripts and data made available to us through the cooperation of many who share our concerns about OC's in the 1980s. The problems we discuss represent many topics of current or recent concern to natural resources management agencies. We have not attempted to present a complete summary of OC problems in North America.

Trends—The National Pesticide Monitoring Program

The NPMP, established in 1964, is designed to determine national and regional trends in environmental contamination. Fish, starlings *(Sturnus vulgaris)* and wings from hunter-harvested mallards *(Anas platyrhynchos)* and black ducks *(A. rubripes)* collected at two or three year intervals, are used to monitor OC contamination on a river drainage, local, or state basis. Collectively, the three phases of the NPMP provide a compendium of overall OC contamination in fish and wildlife since 1966–67 (White 1979a, 1979b, Schmitt et al. 1981). Trend data reflect registration cancellations and restrictions enacted during this time period (see Table 1 for registration status of some OC's).

The occurrence of DDE in nationwide collections of starlings (112 sites), fish (109 sites), and duck wings (215 pools of wings) exceeded 99 percent for the period

Table 1. Regulatory status of some organochlorine compounds used in the United States during the past three decades.

Chemical	Regulatory status[a]
Aldrin	Cancelled except for limited use, 1974
Chlordane	Cancelled except for limited use, 1980
DDT	Cancelled except for limited use related to human health, 1972
Dieldrin	Cancelled except for limited use, 1974
Endrin	Uses restricted, 1979; environmental applications not uncommon
Heptachlor	Uses restricted, 1980; total phase out scheduled for 1983
Kepone	Cancelled, 1978.
Mirex	Cancelled, 1977.
PCB's	Manufacturing, processing, and distribution prohibited, 1979.
Toxaphene	Cancelled, 1982. Use of existing stocks allowed.

[a]The regulatory status presented here is an over-simplification of use regulations but summarizes restrictions of major environmental importance. See EPA's "Suspended and Cancelled Pesticides" (1979) for additional details.

1979–80 (Cain 1981, B. W. Cain and C. M. Bunck, unpubl. ms., C. J. Schmitt et al., unpubl. ms.). However, significant declines in DDE (50 to 60 percent) and DDT (75 percent or more) concentrations in these samples have occurred since the late 1960s. Though the frequency of occurrence remains high, the downward trend in DDE and DDT concentrations indicates that the discontinued use of DDT in the United States has resulted in a dramatic improvement in the chemical environment.

The frequency of occurrence of PCB's also remains high; it exceeded 83 percent in starlings, duck wings, and fish in the 1978–80 NPMP samples. The prevalence of PCB's in mallard wings actually increased from 39 percent in 1976–77 to 95 percent in 1979–80 (White 1979b, Cain 1981). Concentrations of PCB's in fish and wildlife samples indicate no significant decline of PCB's through 1980.

Concentrations of PCB's in wildlife exhibit strong geographical differences, whereas regional differences in DDE concentrations are not pronounced. In fish, duck wings, and starlings, PCB concentrations tend to be highest in the Northeast and Midwest. However, significant PCB concentrations (1 ppm or more)[1] were common in fish near most major population centers sampled (C. J. Schmitt et al., unpubl. ms.).

Trends are more difficult to establish for OC's other than DDT and PCB's because of their less frequent occurrence in wildlife samples. However, 46, 25, and 20 percent of the duck wing pools in 1979–80 contained detectable levels of dieldrin, heptachlor epoxide (HE), and various chlordane isomers, respectively (Cain 1981). The incidence and mean concentrations of these compounds in fish

[1]All residues are expressed as ppm (ug/g) on a wet weight basis.

in 1978–79 were even greater than in duck wings (C. J. Schmitt et al., unpubl. ms.).

Recent Use

Heptachlor Seed Treatment in Oregon Decreases Canada Goose and American Kestrel Productivity

In 1976 and 1977, die-offs of several species of birds occurred in Umatilla and Morrow counties, Oregon. Lethal concentrations of HE (Stickel et al. 1979a) were found in the brains of ring-necked pheasants *(Phasianus colchicus),* black-billed magpies *(Pica pica),* California quail *(Callipepla californica),* and Canada geese *(Branta canadensis moffitti)* (Blus et al. 1979).

High HE concentrations also were found in Canada goose eggs at Umatilla National Wildlife Refuge (NWR) in 1977 and 1978. HE concentrations in these eggs were correlated with nesting success (Blus et al. 1979). Geese apparently acquired the HE by ingesting seeds treated with heptachlor for wireworm control. A local ban on heptachlor seed treatment in 1979 was followed by a dramatic decrease in HE concentrations in Canada goose eggs (geometric mean = 2.93 ppm in 1978, 1.49 in 1979, and < 0.20 in 1980) and equally dramatic increases in the percentage of successful nests (52–53 percent in 1978–79 and 77–84 percent in 1980–81) and eggs hatched per active nest (< 3 in 1978–79 and > 4 in 1980–81; L. J. Blus, unpubl. data).

Heptachlor from the seed treatments also entered the food chain of American kestrels *(Falco sparverius),* causing a decrease in productivity. Eggs from 22 percent of the nests sampled in 1979 contained HE concentrations that were correlated with reduced hatching success. Only 8 and 4 percent of the nests sampled in 1980 and 1981 contained eggs with such high concentrations (Henny et al. 1983). Furthermore, HE residues were detected in eggs from 9 of 10 other species of hawks and owls sampled (C. J. Henny et al., unpubl. ms.). Three golden eagles *(Aquila chrysaetos)* and several other raptors died of heptachlor poisoning in the two-county study area (See Predatory Bird section). Clearly, heptachlor treated seed constitutes a threat to birds at several trophic levels.

In the Umatilla region of Oregon, heptachlor was replaced by lindane as a seed treatment in 1979. Lindane also is an organochlorine pesticide, but is of much lower toxicity (Hill et al. 1975). Since its use in Oregon began in 1979, lindane has been found in only 2 of 176 kestrel eggs and in no goose eggs.

Endrin Threatened 1981 Waterfowl Hunting Season in 17 States

In the spring of 1981, over 100,000 ha of wheatlands in the Great Plains, principally in Montana and Wyoming, were sprayed with endrin to control army cutworms (S. H. Allen et al., unpubl. rep.). Waterfowl and upland game birds collected from portions of Montana in summer 1981 had endrin concentrations in their tissues that exceeded tolerances established for poultry products intended for human consumption. As a result, concern for public health threatened to cancel waterfowl seasons in 17 states.

Hunting seasons were eventually opened, but some states advised that precautions should be taken to reduce the consumption of wild game, especially by nursing mothers and pregnant women.

Montana instituted a license refund policy for those who no longer desired to hunt. License sales in Montana were off 50 percent. In addition, the endrin incident cost the state an estimated $5.6-million in hunting-related income (Schneider 1982).

Endrin is highly toxic (Hill et al. 1975) and could have caused direct mortality or reproductive impairment (see Fleming et al. 1982, Blus 1982). However, reproductive effects were not evaluated in endrin-sprayed areas of Montana in 1981. Endrin was again used in Montana in 1982, though the total area sprayed was only about 4,940 acres (2,000 ha).

Endrin Use Results in Avian Mortality in Washington State Orchards

From October 1981 through July 1982, 91 birds were found dead in or near orchards in the Wenatchee area of Washington (Blus et al. 1983a). Brains of 36 of 78 (46 percent) birds analyzed contained diagnostically lethal concentrations of endrin as judged by the criteria of Stickel et al. (1979b). Endrin is applied to the base of trees in the orchards in the fall to control small rodents. Most reported bird mortalities occurred from November through March. Further details are reported elsewhere in this transactions (Blus et al. 1983a).

Contamination Related to Historical Sources

Dieldrin-induced Mortality of Gray Bats in Missouri, 1976–81.

Dieldrin poisoning occurred during 1976–78 in two maternity colonies of the endangered gray bat *(Myotis grisescens)* in Franklin County, Missouri (Clark et al. 1978, 1980, 1983, unpubl. ms.). Residues of heptachlor-related chemicals in bats from these caves increased markedly in 1977 to potentially dangerous concentrations and remained elevated in 1978. The more severely contaminated colony disappeared in 1979 and was not present when the roost caves were visited in 1982.

Dead gray bats were also found in two caves used as transient roosts by gray bats in Boone County, Missouri. A subsample of 42 dead bats collected in 1980–81 were analyzed and all contained lethal levels of dieldrin and high concentrations of heptachlor-related compounds (Clark et al. 1983).

Dieldrin residues in bats probably resulted from use of aldrin (which breaks down to dieldrin) in the early 1970s to control cutworms in corn. The high concentrations of heptachlor-related compounds were probably the result of heptachlor use on corn following the banning of aldrin in 1974. Heptachlor was recommended by the State of Missouri as a substitute and was used through 1981.

Heavy DDT Contamination at Wheeler NWR, Alabama

A DDT manufacturing plant operated at the Redstone Arsenal, adjacent to Wheeler NWR from 1947 to 1970. In 1978, the U.S. Army Corps of Engineers reported that sediments in a 2.4 mile (3.8 km) portion of a stream on Wheeler NWR contained an estimated 8.0×10^6 pounds (3.63×10^6kg) (later revised to 1.6×10^6 pounds [7.3×10^5kg]) of DDT and its metabolites (Fleming and Atkeson 1980). Wheeler NWR serves as a wintering refuge for up to 90,000 ducks and geese annually. In 1978 and 1979, mallards were collected from the most heavily contaminated portion of the Refuge and analyzed for OC's. In both years, more than 40 percent of the mallards contained carcass concentrations of DDE exceeding 3.4 ppm (Fleming and Atkeson 1980, W. J. Fleming, unpubl. data), a level that has been associated with poor reproductive performance in black ducks (Longcore and Stendell 1977). One immature famale mallard contained 480 ppm DDE in 1978.

Refuge records show that a severe population decline of several avian species occurred on the Refuge during the 1950s and 1960s (Fleming and Atkeson 1980). Herons, eagles, and other carnivorous birds still remain at risk from consuming fish, ducks, and other prey items at Wheeler NWR. Concentrations of DDT and its metabolites in fish from portions of the Refuge in 1979 frequently exceeded 100 ppm with occasional samples above 1000 ppm (Water and Air Research, Inc. 1980). Diets containing 3 ppm DDE cause eggshell thinning or poor reproductive success in kestrels, screech owls *(Otus asio),* and barn owls *(Tyto alba)* (Wiemeyer and Porter 1970, McLane and Hall 1972, Mendenhall et al. 1983).

From 1979 to 1981, the U.S. Army took several steps to prevent further contamination of waterways draining the old DDT manufacturing site. Mitigative alternatives are being examined both to prevent further transport of DDT downstream to the Tennessee River and to clean up the more heavily contaminated portions of Wheeler NWR. However, the time projected for completion of clean-up activities is about 10 years. The effectiveness of the clean-up operation can only be evaluated with time, but it is evident that there will be a DDT problem of significance at Wheeler NWR, probably through the remainder of the decade if not the century.

High Concentrations of OC's in Fish at Yazoo NWR, Mississippi

Routine pesticide monitoring can turn up unexpected problem areas. In 1982, fish samples were collected from portions of Yazoo NWR as part of a fisheries evaluation. DDE, toxaphene, dieldrin, and endrin were as high as 13, 324, 7.5, and 2.4 ppm, respectively, in gizzard shad *(Dorosoma cepedianum).* Other fish species also contained high residues of some OC's (W. W. Johnson, pers. comm.). Such high concentrations of OC's in the diets of predatory birds might decrease productivity or cause outright mortality.

High concentrations of OC pesticides also were found in fish taken from the Yazoo River near Redwood, Mississippi (the Yazoo River does not flow through the Yazoo NWR), about 50 miles (80 km) from the Refuge (C. J. Schmitt et al., unpubl. ms.). Historical use of OC's on cotton fields around the Refuge is the suspected source of contamination.

Duck Hunters in New York and New Jersey Warned about PCB's

In 1981 and 1982, duck hunters in New York and New Jersey were cautioned about the consumption of wild waterfowl (W. B. Stone, pers. comm.). This was the result of a 1979–80 study of OC concentrations in a mixed sample of waterfowl principally from the Hudson and Niagara rivers. Fish from the Hudson River in 1978 contained up to 110 times the national average PCB concentration for fish in the NPMP (C. J. Schmitt et al., unpubl. ms.). Waterfowl from these two rivers contained PCB's in excess of tolerances established by the FDA for poultry. The PCB concentrations found in these waterfowl were below levels associated with reproductive impairment or decreased survival (Custer and Heinz 1980, Haseltine and Prouty 1980, Heath et al. 1972, Heinz et al. 1983). However, other species of birds appear to be more sensitive to PCB's than waterfowl (Dahlgren and Linder 1971, Peakall and Peakall 1973). Among mammals, mink *(Mustela vision)* appear to be especially sensitive to PCB's; only 0.64 ppm PCB's in the diet of mink caused reproductive failure and 1 ppm caused death (Aulerich et al. 1971, 1973). In 1981, a moribund great horned owl *(Bubo virginianus)* found near the Hudson River had 360 ppm PCB's in its brain (Stone and Okoniewski 1983), a concentration within the lethal range as determined by L. F. Stickel et al. (1983). Therefore, PCB levels in New York may present a hazard to some wildlife species and deserve additional attention.

Organochlorine Contaminants in the Great Lakes

Residues of DDE in the Great Lakes fishery appear to be decreasing. DDE residues in spottail shiners *(Notropis hudsonius)* decreased 26–89 percent in different areas of the Lower Great Lakes between 1975 and 1979 (Suns et al. 1981). However, DDE concentrations in fish from Lake Michigan in the 1978–79 NPMP still averaged among the highest in the nation (1.24–1.97 ppm). No fish from the other Great Lakes showed this high degree of DDE contamination (C. J. Schmitt et al., unpubl. ms.).

Mean PCB concentrations ranged up to 5.9 ppm in fish from the Great Lakes in the 1978–79 NPMP (Schmitt et al., unpubl. ms.). Herring gull *(Larus argentatus)* eggs from Snake Island in Lake Ontario, contained 86 ± 41 ppm PCB's in 1981, and eggs from other gull colonies on the Great Lakes averaged 23 ppm or more (D. V. Weseloh, pers. comm.).

Dieldrin concentrations in bloaters *(Coregonus hoyi)* from Lake Michigan doubled between 1969 and 1978 (International Joint Commission 1979) with values up to 0.72 ppm (C. J. Schmitt et al., unpubl. ms.). This trend is in the opposite direction from that seen throughout the rest of the United States (C. J. Schmitt et al., unpubl. ms.). Concentrations of chlordane in fish from the Great Lakes were among the highest found in the 1978–79 NPMP.

Concentrations of toxaphene, an insecticide heavily used on cotton, have been increasing in areas outside cotton-growing regions. Toxaphene concentrations in Lake Michigan now average as high as in fish from some cotton-producing states. Toxaphene residues in lake trout *(Salvelinus namaycush)* from Lake Michigan typically were in the 5–10 ppm range in 1978–79 (C. J. Schmitt et al., unpubl. ms.).

Gulls are the only birds extensively monitored for organochlorine contaminants on the Great Lakes. Herring gulls from the Great Lakes have among the highest levels of OC contamination known for the species worldwide (Weseloh and Mineau 1979). Fortunately, the present high level of contamination is down from past years and is now below any apparent effect level (D. V. Weseloh, pers. comm.). Red-breasted merganser *(Mergus serrator)* eggs from Lake Michigan in 1977 and 1978 showed relatively high levels of PCB's (4.9–229 ppm), DDE (2.3–28 ppm), and dieldrin (0.2–2.3 ppm), but again, no reproductive effects were found (Haseltine et al. 1981, Heinz et al. 1983).

Thus, levels of OC contamination in the Great Lakes region have declined considerably, but still remain high. Present levels of OC contamination do not appear to be adversely affecting the wildlife populations in the area but only a few species have been studied.

Other Problem Areas

Other isolated instances of moderate to heavy organochlorine contamination, about which little is known, cover many chemicals and geographical locations. Fish from Manoa Stream at Honolulu contained the highest mean dieldrin (1.99 ppm), chlordane (4.87 ppm), and heptachlor (0.80 ppm) concentrations in fish sampled in the NPMP in 1978–79 (C. J. Schmitt et al., unpubl. ms.). Also in Hawaii, milk products were withdrawn from grocery stores and school cafeterias on Oahu in 1982 after 3–6 times the acceptable level of heptachlor were found in dairy products. Cows had been fed the tops of heptachlor-treated pineapple plants (Smith 1982). The effects of the continued use of heptachlor on the fauna of the Hawaiian Islands has not been investigated, but the Oregon example cited earlier in this paper demonstrates the potential for dramatic environmental effects resulting from some heptachlor uses.

Fish from the Southeast, a region not normally considered to have high environmental levels of PCB's, contained in excess of 20 ppm PCB's from seven sites, including as much as 140 ppm in fish from Lake Hartwell, South Carolina (Veith et al. 1979). Perhaps the river most heavily contaminated with PCB's is the Sheboygan River in Wisconsin; PCB residues in 40 samples of fish from a highly contaminated section of the river contained an average of 155 ppm PCB's and one carp *(Cyprinus carpio)* contained 970 ppm (Kleinert et al. 1978). Birds shot as they were feeding along the Sheboygan River contained from 23 to 218 ppm PCB's in their carcasses (Heinz et al. unpubl. ms.).

Starlings from 12 of 112 counties surveyed in the NPMP have rather consistently contained elevated concentrations of DDE (B. W. Cain and C. M. Bunck, unpubl. ms.). DDE concentrations (in ppm) in starlings from these locations in 1979 were: Maricopa County, Arizona, 6.44; Lonoke County, Arkansas, 1.27; Ventura, Monterey, Kern, and Imperial counties, California, 2.11, 1.46, 1.68, and 2.72, respectively; Union and Pender counties, North Carolina, 1.27 and 1.49; Aiken County, South Carolina, 2.26; Kinney County, Texas. The high level of DDE contamination in starlings from Maricopa County, Arizona and Chaves County New Mexico is discussed in the following section. The high level of contamination at the Arkansas site is probably the result of a former DDT plant on the Arkansas River at Pine Bluff, Arkansas. The source of the contamination at the other sites is unknown but possibly related to former agricultural use of DDT. DDE at many of these sites is sufficiently abundant to give reason for concern about it effects on sensitive wildlife species.

Contamination From Undetermined Sources

DDT in New Mexico and Arizona

Large areas of New Mexico (Pecos River Valley from Roswell south, and the Guadalupe Mountains) and Arizona (Gila River from Goodyear to Painted Rock Reservoir) are contaminated with DDT, principally as the metabolite DDE. Starlings collected from Chaves County, New Mexico, and Maricopa County, Arizona, contained the highest (15.80 ppm) and second highest (6.44 ppm) residues of DDE among 126 sites across the U.S. in 1979 and far exceeded the national average of 0.56 ppm. Whereas DDE decreased significantly in starlings nationwide between 1976 and 1979, concentrations increased at these two sites (B. W. Cain and C. M. Bunck, unpubl. ms.).

Pools of wings from mallards killed in 1979–80 in the eastern Gila and Verde Rivers in Arizona (most wings were from a site near Buckeye, Arizona) contained high DDE concentrations, up to 5.95 ppm (W. J. Fleming and B. W. Cain, unpubl. ms.). On a lipid weight basis, the muscle of ducks from the Gila River averaged higher residues than those from the industrially contaminated site at Wheeler NWR (D. R. Clark and A. J. Krynitsky, 1983, O'Shea et al. 1980). Fish collected in 1980 from the Painted Rock Reservoir and from the Gila River near Buckeye, Arizona, contained high DDE levels (up to 9.56 ppm and 6.68 ppm in whole fish, respectively; H. D. Kennedy, pers. comm.). DDT and metabolite concentrations in some fish and ducks in the Arizona area exceed tolerances established for human food in the market place.

Recent studies of songbirds in New Mexico have shown DDE residues up to 33 ppm in the Guadalupe Mountains area (L. R. DeWeese, unpubl. ms.; C. Sanchez, pers. comm.). Free-tailed bats *(Tadarida brasiliensis)* from Carlsbad, New Mexico in 1976 (the most recent data available) contained DDE concentrations that were potentially lethal to bats at times of energy stress (Geluso et al. 1976, 1981).

Actual impacts of this contamination are not well quantified. Reproduction of the peregrine falcon *(Falco peregrinus)* in northern New Mexico was recently shown to be impaired by DDE (Enderson et al. 1982). Furthermore, the high DDE levels in songbirds in New Mexico and in starlings and fish in Arizona represent a threat to other predatory birds.

The source of this contamination is under investigation. Current use of DDT or pesticides contaminated with DDT has been suggested to account for part of this contamination (Clark and Krynitsky 1983).

DDE Decrease Black-Crowned Night-Heron Productivity in the Intermountain West

Organochlorine contamination was studied in eight black-crowned night-heron *(Nycticorax nycticorax)* populations nesting in Washington, Oregon, and Nevada in 1978–80. DDE was detected in all 220 eggs sampled and eggshell thickness was negatively correlated with residues of DDE and with PCBs (Henny et al. 1984). Maximum DDT and DDE concentrations in eggs ranged up to 18 and 130 ppm, with these highest values coming from Ruby Lake NWR in Nevada. Ten to 59 percent of the nests sampled in each colony contained DDE in excess of 8 ppm, a level which was associated with decreased clutch size and percentage of nests yielding fledged young, and increased incidence of cracked eggs. Productivity of the Ruby Lake colony, where DDE concentration in eggs averaged over 8 ppm in 1979, was below the level required for population maintenance (Henny 1972).

There is no evidence of heavy contamination immediately around breeding areas. Wintering grounds or migration points are the probable sources of DDE for these birds. Band recovery and telemetry data indicate (Henny et al. 1984, Henny, unpubl. data) that black-crowned night-herons from Ruby Lake NWR winter in Mexico (where present contaminant levels are not known) and in the southwestern United States (where several areas of heavy DDE contamination have been identified).

On a positive note, DDE residues in the colonies studied showed a significant decline from 1979 to 1982 (Henny et al. 1984, C. J. Henny, unpubl. data).

High Levels of DDE in Potential Peregrine Falcon Prey Items in the Rocky Mountains

Twenty-nine species of small birds known to be prey of peregrine falcons were collected near peregrine eyries in Colorado and New Mexico during May and June from 1977 through 1979 (Enderson et al. 1982). DDE averaged 0.5 ppm or more in 7 of 12 species considered important prey items; Brewer's blackbird *(Euphagus cyanocephalus)* was the most highly contaminated, averaging 6.0 ppm DDE. Species of lesser importance as peregrine prey had DDE concentrations ranging up to 32 ppm; killdeer *(Charadrius vociferus)* were the most contaminated. More recent sampling of over 1,200 song and shorebirds in the Rocky Mountains yielded similar results. With some exceptions, high residues were found in migrants but not in resident species (L. R. DeWeese and L. C. McEwen, pers. comm.). Enderson et al. (1982) considered these DDE levels to be detrimental to peregrine reproduction.

Comparison of migratory and resident birds indicates that the DDE is being acquired on wintering grounds or migration stop-over sites. Migratory, granivorous birds averaged two times more DDE than resident granivores. Likewise, migrant onmivores and insectivores averaged 4 and 94 times more DDE than resident species with comparable food habits (Enderson et al. 1982).

Endrin Kills White Pelicans at Klamath Basin NWR, California

Small numbers of white pelicans *(Pelecanus erythrorhynchos)* are found dead each year on their breeding grounds at Klamath Basin NWR in California. Seventeen of 24 dead pelicans found at the Refuge contained lethal or hazardous levels of endrin in their brains. As recently as 1981, pelicans at Klamath Basin NWR died from endrin poisoning. Dieldrin concentrations were also high in the brains of some of these pelicans and may have contributed to some deaths. Furthermore, white pelicans at Pyramid Lake, Nevada died from endrin poisoning in 1980 and in 1981.

There has been no reported use of endrin in the Klamath Basin in recent years. Fish samples from the Klamath Basin NWR contained no detectable endrin residues (H. M. Ohlendorf, pers. comm.).

High Concentrations of DDE Black Skimmer Eggs from the Texas Coast

Black skimmer *(Rynchops nigra)* eggs collected at the Lower Laguna Madre, Texas in 1979–81 contained up to 64 ppm DDE. In each of these years, more than 50 percent of the eggs collected contained 10 ppm or more DDE. The significance of these residues to skimmers remains unknown (D. W. White, pers. comm.). Whether high DDE residues have a role in the 22 percent decline (Texas Colonial

Waterbird Society 1982) of nesting skimmers on the Texas Coast from 1974 through 1981 is also unknown.

Studies are underway to determine whether these birds acquire the DDE burdens on their nesting grounds or perhaps on wintering grounds further south.

High Concentrations of DDE Caspian Terns in California

In 1981, DDE concentrations in eggs from 25 randomly selected Caspian tern *(Hydroprogne caspia)* nests in San Diego Bay ranged from 2.7 to 34 ppm (H. M. Ohlendorf, pers. comm.). Another egg in which the chick died while hatching contained 56 ppm DDE. Eggshell thickness was negatively correlated with DDE, and cracked and crushed eggs were found in the colony.

Again, the source of these residues is not known. Fish from San Diego Bay, brought by adult terns to their chicks in 1981, generally contained less than 0.7 ppm DDE but one sample contained 3 ppm. These concentrations of DDE in fish from San Diego Bay could contribute to the high DDE levels in eggs, but terns also could acquire significant DDE burdens elsewhere.

Predatory Birds

In most regions of North America, populations of brown pelicans *(Pelecanus occidentalis),* bald eagles *(Haliaeetus leucocephalus),* peregrine falcons, and ospreys *(Pandion haliaetus)* have improved since the 1960s. The recovery of these populations is largely due to a decrease in DDE in the environment (Anderson et al. 1975, Grier 1982, Henny 1977, Henny 1983, Henny et al. 1982a, Henny et al. 1982b, Mendenhall and Prouty 1978, Spitzer et al. 1978). However, DDE remains high in peregrine falcons in the Rocky Mountains and is believed to be limiting the improvement of this regional population (Enderson et al. 1982).

Raptors that died from OC poisoning in recent years include an adult female Cooper's hawk *(Accipiter cooperii)* from Colorado in 1980 from DDT (Prouty et al. 1982), an adult female great horned owl from Oregon in 1980, a red-shouldered hawk *(Buteo lineatus)* from Maryland in 1978, and another from Alabama in 1981, all from chlordane (Blus et al. 1983b). From 1978–81, five bald eagles died with lethal residues of dieldrin in their brains (W. L. Reichel, pers. comm.).

Other raptors that died of OC poisoning were directly associated with known OC applications. Lethal residues of HE were found in 1977–1980 in an American kestrel, a rough-legged hawk *(Buteo lagopus),* and three golden eagles in an area of Oregon where heptachlor was used as a seed treatment (Henny et al. 1983, C. J. Henny et al., unpubl. ms.). Lethal residues of endrin were found from 1981 to 1982 in three barn owls *(Tyto alba),* three sharp-shinned hawks *(Accipiter striatus),* three Cooper's hawks, two goshawks *(Accipiter gentilis),* and one great horned owl in orchards in Washington where endrin is used for rodent control (Blus et al. 1983a).

Summary and Conclusions

In general, decreases in OC contamination in North America are unmistakable. This is documented by the NPMP, but, more importantly, it is borne out by improvements in the reproduction and population status of the brown pelican, bald eagle, peregrine falcon, and osprey. However, some OC contamination still persists, and several species, particularily predatory birds and insectivorous bats, continue to be vulnerable.

Current OC problems in North America result from present and past usage and from industrial contamination. In addition, some studies suggest that some migrant bird species that winter south of the U.S. border are exposed to higher levels of OC pesticide than non-migrants. However, heavy OC pesticide contamination is known to exist in Arizona, New Mexico, and in southern California where migratory birds might stop during migration. At this time, we do not have the information to assess specifically the sources of contamination for most migrant species.

From the number of recent OC problems identified in North America, it is apparent that OC's are not confined to the past and that we must continue to monitor and study OC's during this decade. However, current administrative, management, and research priorities are being directed toward the search for potential impacts of newer pesticides, air pollution, industrial waste, and other contaminants. Although it is necessary to build a body of scientific data on these types of contaminants, we feel that we cannot neglect continued work on OC's for which harmful effects impacting our wildlife resources are already known.

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Assessing Hazards of Organophosphate Pesticides to Wildlife

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Introduction

Organophosphates (OPs) are the most widely used group of pesticides in North America and their use has resulted in concern over their possible effects on wildlife. A significant amount of research has been conducted on the effects of OPs on wildlife within the last decade, but results have not been summarized and research needs have not been well defined.

The objectives of the present paper are to review the potential effects of OPs on wildlife (amphibians, reptiles, birds, and mammals), to identify research needs, and to suggest approaches by which needed data may be obtained. We also briefly describe the mode of action of OPs, the criteria used to assess exposure, and the routes by which wildlife may be exposed, an understanding of which is necessary to assess the potential hazards of these chemicals to wildlife populations.

Mode of Action and Recovery

Organophosphates act by inhibiting (phosphorylating) the enzyme cholinesterase (ChE), causing an accumulation of acetylcholine at nerve synapses and consequent disruption of nerve function (O'Brien 1967:55). The ability of OPs to inhibit ChE varies among chemicals (Su et al. 1971, Fleming 1981, Hall and Clark 1982), animal species (Murphy et al. 1968, Andersen et al. 1977, Fleming and Grue 1981), ages (Benke and Murphy 1975), and sexes (Agarwal et al. 1982), and with the level of exposure (Fleming and Grue 1981, Busby et al. 1983). Dietary deficiences may also affect ChE inhibition (Casterline and Williams 1971).

The action of OPs is not restricted to ChE. OPs also inhibit a number of other esterases, some of which are responsible for metabolism and detoxification of OPs (DuBois et al. 1968, Murphy and Cheever 1968). Several of these esterases appear to be more sensitive than ChE to OP exposure, and the inhibition of some of them may be the mechanism by which exposure to one OP potentiates the toxic effects of another (DuBois et al. 1968, Murphy and Cheever 1968). Exposure to some OPs may also produce delayed neuropathy due to the inhibition of neurotoxic esterase (for review, see Davis and Richardson 1980).

Complete recovery of ChE activity in vertebrates that survive OP exposure occurs primarily by dephosphorylation (spontaneous reactivation) of inhibited ChE and by the synthesis of new ChE (O'Brien 1967:46–48). In birds and mammals, the rate of recovery of acetylcholinesterase (AChE, the primary ChE in the central nervous system and erythrocytes, as opposed to butyrylcholinesterase, which is found in the plasma) appears to depend on the OP and the maximum degree of ChE depression (Fleming and Bradbury 1981). Initial recovery of AChE in birds and mammals to 50 to 60 percent of normal is rapid, followed by a slower rate of recovery until normal levels are attained (Robinson and Beiergrohslein 1980, Fleming 1981, and references therein). In birds, the time required for brain ChE to reach normal values (80%, about 2 SD below average values of controls) is probably less than 30 days (Fleming and Grue 1981, Busby et al. 1983). Plasma ChE activity appears to recover at a rate equal to or exceeding that of brain ChE in both birds and mammals (DuBois et al. 1968, Fleming 1981).

Monitoring Exposure and Diagnosing Mortality

Identifying and monitoring exposure to OPs is the initial step in assessing the impacts of these chemicals on wildlife populations. In most instances, chemical analysis of tissues is of little value because most OPs are metabolized and eliminated rapidly. However, measurement of ChE activity in brain tissue, erythrocytes (RBC), and plasma has been used to monitor exposure to or diagnose mortality from ChE inhibitors. In birds and reptiles, brain ChE inhibition of 50 percent or more in dead individuals, compared with that of comparable controls, is indicative of poisoning by a ChE inhibitor (Ludke et al. 1975, Hall and Clark 1982). Criteria for diagnosing poisoning of amphibian and mammalian wildlife by anti-ChE compounds have not been established. Chemical analyses of ingesta can confirm diagnosis of OP poisoning in some instances (Hill and Fleming 1982).

Although brain ChE activity in birds that die from exposure to an anti-ChE compound is usually depressed by at least 50 percent of controls, similar inhibition in living birds does not necessarily mean that these individuals will die (Ludke et al. 1975). One can only conclude that those birds have been exposed to a ChE inhibitor.

Brain ChE activity has also been used to monitor sublethal exposure of OPs in amphibians (Guzman and Guardia 1978), reptiles (Hall and Clark 1982), birds (Busby et al. 1981, 1983), and mammals (Zinkl et al. 1980). Results of laboratory studies (Ludke et al. 1975) suggest that brain ChE depression of 20 percent (2 SD below average values of controls) or more is indicative of OP exposure in birds. Hall and Clark (1982) found that brain ChE inhibition of 40 percent is indicative of sublethal exposure in reptiles.

Erythrocyte and plasma ChE can be used to monitor OP exposure in living animals. This offers some advantages in studies where repeated sampling is necessary or where sacrifice of animals is impractical. However, interpretation of RBC and plasma ChE inhibition is more difficult than that of brain ChE because little is known about their function (Kutty 1980). Also, inhibition of RBC and plasma ChE bears no well established relationship to brain ChE inhibition (Frawley et al. 1963, Clark 1971, Ecobichon and Zelt 1979, Fleming 1981). Methods for determining and interpreting ChE levels in brain and blood have been reviewed by Hill and Fleming (1982).

Routes and Duration of Exposure

Wildlife may be exposed to OPs in many ways. The use of OPs as seed treatments may represent a significant route of exposure for granivorous species. Ingestion of a relatively small number of seeds can produce toxic effects (Stromborg 1977). Exposure of wildlife to seed treatments does not appear to be limited to seed remaining on the soil surface: mortality of greylag geese *(Anser anser)* was attributed to the uprooting and consumption of germinating OP-treated seeds (Hamilton and Stanley 1975).

Residues on treated vegetation constitute another route of exposure of wildlife to OPs. Treatments to control insects on newly emergent small grains and turf have resulted in several incidents of mortality in herbivorous birds, particularly ducks and geese (e.g., Nettles 1976, Stone 1979, White et al. 1982a,b). More than 10,000 American robins *(Turdus migratorius)* died after consuming berries on plants surrounding fields treated with monocrotophos[1] (Stevenson 1972).

Secondary poisoning of wildlife by means of consumption of dead or struggling insects that have been poisoned is considered to be an important route of exposure of wildlife to OPs (Stickel 1974). Birds have been observed feeding on poisoned insects following applications of parathion and fensulfothion to turf (Mills 1973). In other field studies, several species of birds and small mammals increased their consumption of arthropods following application of acephate or trichlorfon (Stehn et al. 1976, DeWeese et al. 1979). Mortality of nestling and adult laughing gulls *(Larus atricilla)* was attributed to consumption of insects poisoned by parathion (White et al. 1979). Although consumption of poisoned insects appears to be a major route of exposure, studies that have quantified concentrations of OPs and their metabolites in insects have found residues to be below those lethal to wildlife (McEwen et al. 1972, Stromborg et al. 1982).

Ingestion of OP-poisoned vertebrates (birds and small mammals) also has resulted in mortality of avian and mammalian wildlife under field conditions (Mills 1973, Mendelssohn and Paz 1977). In the laboratory, brain and plasma ChE were severely depressed in barns owls *(Tyto alba)* fed Japanese quail *(Coturnix c. japonica)* poisoned with famphur (Hill and Mendenhall 1980). Tadpoles *(Rana catesbeiana)* held in experimental chambers concentrated parathion and fenthion to levels that were lethal to mallards *(Anas platyrhynchos)* (Hall and Kolbe 1980), however, tests in the laboratory (Fleming et al. 1982) and field (Powell et al. 1982) have failed to demonstrate similar concentration of OPs by adult frogs.

Granular forms of OPs present hazards similar to treated seeds. Pesticide granules may be consumed as grit or seed by granivorous birds or ingested with food. Ingestion of only a few granules may cause mortality because of the relatively large amount of active ingredient applied to the carrier granules. Consumption of unwashed granules on the soil surface has resulted in the mortality of waterfowl (Stone 1979). Wildlife may also be exposed to OPs by consuming vegetation or insects contaminated with these chemicals after they are washed from the carrier granules (Mills 1973).

[1]Names of chemicals in text are common names of OPs according to Chemical Abstracts, 9th Chemical Index.

Dermal absorption and inhalation have been recognized as potential routes of exposure (Fowle 1972, Mills 1973, Hudson et al. 1979), but their significance has not been assessed adequately. Dermal contact with OPs has been documented in wildlife following pesticide applications, and laboratory studies have shown that dermal exposure can result in OP poisoning (Gaines 1969, Fowle 1972, Hudson et al. 1972, Pope and Ward 1972, Guzman and Guardia 1978). Purple finches *(Carpodacus purpureus)* and a white-throated sparrow *(Zonotrichia albicollis)* that inhaled phosphamidon vapors for up to 9 hours did not appear to suffer any ill effects (Fowle 1972). Whereas the results of Weeks et al. (1977) suggest that a greater hazard exists from inhalation than from ingestion of equivalent amounts of malathion in laboratory rabbits and quail, Berteau and Chiles (1978) found the toxicity of acephate and methamidophos to laboratory mice, rats, and quail did not differ significantly between the two routes of exposure.

Petroleum may be transferred from the plumage of birds to their eggs during incubation (King and Lefever 1979, Albers 1980). Because petroleum products are used as carriers in some pesticide formulations, transfer of pesticides from feet or plumage to eggs or young may occur. The potential for the transfer of pesticides in other carriers from adult birds to their eggs or young has not been investigated.

The duration of exposure of animals to OPs is dependent on the persistence of the pesticide in the environment and on the metabolic capabilities of exposed animals. Persistence of OPs in the environment is affected by many chemical, physical, and biological variables which are too complex to review here. However, the persistence of most OPs in water (Freed et al. 1979), soil (Harris 1969), foliage (Varty and Yule 1976), invertebrates (Stromborg et al. 1982), birds (Akhtar and Foster 1981), and mammals (Tschaplinski and Gardner 1981) ranges from a few hours to several weeks. That brain ChE inhibition (25–43%) has been reported in birds and mammals 25 to 33 days after OP applications (Zinkl et al. 1979, 1980) also suggests that residues of OPs or their metabolites may persist for several weeks.

Direct Toxic Effects

OP poisoning in wildlife is frequently characterized by anorexia, lethargy, piloerection, antagonistic behavior, miosis and phonation, muscular incoordination, and convulsions or tetany preceding death (O'Brien 1967:56, Tucker and Crabtree 1970).

Mortality

Mortality is often the most obvious effect that OP applications have on wildlife, and sometimes is more easily quantified than many other effects. We found reports of 31 confirmed incidents of wildlife mortality (26 unintentional [Table 1]; 5 intentional [Stone 1979, E. L. Flickinger, D. H. White, C. A. Mitchell, and T. G. Lamont, unpubl. ms.]) due to OP poisoning in North America and over 387 (27 unintentional [Table 1], >360 intentional [Bruijns 1963, Brown et al. 1977, Mendelssohn and Paz 1977, Hamilton et al. 1981b]) in other parts of the world. Estimates of the magnitude of unintentional poisonings range from a few individuals (e.g., Nettles 1976, Zinkl et al. 1981) to 2.9 million (Pearce et al. 1976). Of these incidents, only a small number are known to have been associated with improper

Table 1. Incidents of unintentional poisoning of wildlife by organophosphate pesticides. (Letters in parentheses denote references listed at the bottom of table.)

Chemical[a]	Number of incidents	Wildlife affected[b]
		Within North America
Chlorpyrifos + Diazinon	1	ANATIDAE: Canada goose (A)[c]
Diazinon	4	ANATIDAE: Canada goose (A,B,C), black duck, mallard (A), gadwall, American widgeon, ring-necked duck (C)
Dichlorvos	1 (1)[d]	ANATIDAE: mallard (D)
Famphur	1	CORVIDAE: black-billed magpie (E,F)
Fenitrothion + Phosphamidon	1	MUSCICAPIDAE: ruby-crowned kinglet; EMBERIZIDAE: white-throated sparrow; PARULIDAE: Tennessee warbler, Cape May warbler, ovenbird (G)
Fensulfothion	2 (1)	ANATIDAE (1)[e]: Canada goose (A); PHASIANIDAE (1): wild turkey (H)
Fenthion	5	ARDEIDAE (1): great blue heron, great egret, snowy egret (I); SCOLOPACIDAE (1): Wilson's phalarope; ALAUDIDAE (1): horned lark (J); BOMBYCILLIDAE (1): cedar waxwing (I); MUSCICAPIDAE (1): robin, Swainson's thrush (K); EMBERIZIDAE (1): savannah sparrow (J); PARULIDAE (1): Tennessee warbler, yellow warbler, blackpoll warbler (K); ICTERIDAE (1): yellow-headed blackbird, red-winged blackbird, western meadowlark, Brewer's blackbird, brown-headed cowbird (J); CORVIDAE (1): black-billed magpie (L); LEPORIDAE (1): white-tailed jackrabbit, mountain cottontail; SCIURIDAE (1): Richardson's ground squirrel; CRICETIDAE (1): white-footed mouse (J)
Methyl parathion + Parathion	2	ANATIDAE: white-fronted goose, Canada goose, mallard, pintail (M)
Moncrotophos	1 (1)	MUSCICAPIDAE: robin (N)
Parathion	4 (1)	ANATIDAE (3): white-fronted goose, snow goose, Ross' goose, Canada goose (M,O); LARIDAE (1): laughing gull (P)
Phorate	1	LARIDAE: ring-billed gull (C)
Phosphamidon	3	PHASIANIDAE (3): spruce grouse, blue grouse, ruffed grouse (Q,R,S); TYRANNIDAE (1): yellowbellied flycatcher (R); TROGLODYTIDAE (1): winter wren (S); MUSCICAPIDAE (2): ruby-crowned kinglet (R,S), hermit thrush, Swainson's thrush, robin (S); EMBERIZIDAE (3): chipping sparrow (Q), white-throated sparrow, slate-colored junco (R,S); PARULIDAE (2): Tennessee warbler, magnolia warbler, bay-breasted warbler, yellowthroat (S), Nashville warbler, myrtle warbler, blackburnian warbler (R,S); ICTERIDAE (1): brown-headed cowbird (S); FRINGILLIDAE (1): purple finch, evening grosbeak (S); CORVIDAE (1): blue jay (S)

Table 1. continued

Chemical[a]	Number of incidents	Wildlife affected[b]
		Outside North America
Carbophenothion	7	ANATIDAE: greylag goose (T,U,V), pink-footed goose (U,V), dark-bellied brent geese (W)
Chlorfenvinfos	11	COLUMBIDAE (≥9): woodpigeon, stock dove, feral pigeon (V,X); OTHER (≤2): families or common names not given
Famphur	3	PRUNELLIDAE (1): dunnock; MUSCICAPIDAE (1): robin; CORVIDAE (1): black-billed magpie (Y)
Fensulfothion	2	ACCIPITRIDAE (1): harrier hawk; LARIDAE (1): black-backed gull, black-billed gull; ALAUDIDAE (2): skylark; MOTACILLIDAE (1): pipit; MUSCICAPIDAE (1): blackbird, song thrush; FRINGILLIDAE (2): hedge sparrow, greenfinch, goldfinch, redpoll, chaffinch, yellowhammer; PLOCEIDAE (2): house sparrow; STURNIDAE (2): myna, starling; CRACTICIDAE (2): white-backed magpie; ERINACEIDAE (1): hedgehog; MURIDAE (1): mouse; LEPORIDAE (1): rabbit (Z)
Haloxon	1	No species given (X)
Mevinphos	1	STURNIDAE (1): starling (AA)
Parathion	3	ACCIPITRIDAE (2): harrier hawk (Z), buzzard (BB); FALCONIDAE (1): kestrel (BB); LARIDAE (2): black-backed gull, black-billed gull, red-billed gull (Z), black-headed gull (BB); COLIIDAE (1): speckled coly (CC); ALAUDIDAE (1): skylark (Z); MUSCICAPIDAE (1): blackbird (Z), Jardine's babbler, Kurrichaine thrush (CC); ZOSTEROPODIDAE (1): green white-eye (CC); FRINGILLIDAE (2): greenfinch, goldfinch, redpoll, chaffinch, yellowhammer (Z), yellow-eye (CC); ESTRILDIDAE (1): blue waxbill, melba finch (CC); PLOCEIDAE (1): house sparrow; STURNIDAE (1): starling; CRACTICIDAE (1): white-backed magpie (Z); CORVIDAE (1): rook (BB); ERINACEIDAE (1): hedgehog (Z)

[a]Common name according to Chemical Abstracts, 9th Chemical Index.
[b]Families of birds according to Morony et al. (1975); families of mammals according to Walker (1964); common names given in references.
[c]References: A = Stone 1979; B = Zinkl et al. 1978; C = Hill and Fleming 1982; D = Ludke and Locke 1976; E = Heinz et al. 1979; F = Hill and Mendenhall 1980; G = Pearce et al. 1976; H = Nettles 1976; I = Zinkl et al. 1981; J = DeWeese et al. in press; K = Seabloom et al. 1973; L = Hanson and Howell 1981; M = White et al. 1982b; N = Stevenson 1972; O = White et al. 1982a; P = White et al. 1979; Q = Finley 1965; R = McLeod 1967; S = Fowle 1972; T = Bailey et al. 1972; U = Hamilton and Stanley 1975; V = Stanley and Bunyan 1979; W = Stanley and St. Joseph 1979; X = Stanley and Fletcher 1981; Y = Felton et al. 1981; Z = Mills 1973; AA = Reece and Handson 1982; BB = Koeman 1979; CC = Buttiker 1961.
[d]Number of incidents attributed to misuse of chemical as reported in references.
[e]Number of incidents in which family was involved.

use (Table 1). Seventy-four percent of the unintentional poisonings in North America involved either diazinon, fenthion, parathion, or phosphamidon, and outside North America, 61 percent involved carbophenothion and chlorfenvinphos seed treatments. Although OPs are used as seed treatments in North America, none of the reported incidents of unintentional poisoning were associated with their use. Reasons for this difference and the greater number of intentional wildlife poisonings outside North America are not clear.

We used the mortality data in Table 1, toxicity data (LC_{50}s for 14-day old Japanese quail, Hill et al. 1975, E. F. Hill and M. B. Camardese, unpubl. data), and pesticide use data (amount of active ingredient of each chemical used by farmers in the United States in 1976, Eichers et al. 1978) to determine if toxicity or usage are important factors influencing unintentional OP poisoning of wildlife in North America. Toxicity data were available for 46 (66%) of the approximately 70 OPs registered for use in the United States. We ranked the 46 chemicals according to their toxicity to Japanese quail and divided the ranking into quartiles with the 12 most toxic in quartile I. Use data were available for the 19 most widely used OPs in the United States; we ranked the top 12 (quartile I). If toxicity and usage were important, we would expect the percentage of the OPs involved in unintentional poisonings of North American wildlife (Table 1) in quartile I of each ranking to be significantly greater than 25. Fifty-eight percent of the OPs involved in the die-offs were in toxicity quartile I and 50 percent were in usage quartile I. Seventy-five percent of the OPs involved in unintentional poisonings were found in either toxicity quartile I or usage quartile I. Eighty percent of the OPs used to intentionally poison wildlife in North America were in toxicity quartile I and all were in usage quartile I.

Although toxicity and usage appear to be important factors governing the mortality of wildlife by OPs, they do not appear to be the only factors. For example, based on use and toxicity data alone, one would not expect the number of unintentional poisonings of wildlife in the United States involving methyl parathion (Table 1) to be so low, because this chemical accounts for about 35 percent of all OP usage in the United States (>3.5 times that of other OPs, Eichers et al. 1978) and it is very toxic to birds (Hill et al. 1975). Other factors such as application methodology, pesticide formulation, timing and number of applications, type of habitat treated, and the abundance and diversity of wildlife exposed are also important.

In the unintentional poisonings in North America, birds were the wildlife group most frequently reported (Table 1). The family Anatidae[2] (waterfowl) and particularly the subfamily Anserinae (geese) were the avian groups most often represented (Table 1). Other avian families frequently reported were the Muscicapidae (kinglets, thrushes), Emberizidae (sparrows), and the Parulidae (warblers). Outside North America, the Columbidae (pigeons and doves) and the Anatidae, subfamily Anserinae, were the most frequently poisoned.

Why so few of the incidents of OP poisoning of wildlife involve mammals is not known. Mammals, as a group, appear to be less sensitive to OPs than birds and many are less conspicuous than birds.

[2]Names of families and subfamilies of birds used in text correspond to those given by Morony et al. (1975).

Although young birds and mammals appear to be more sensitive to OPs than adults, we are aware of only one incident (White et al. 1979) of mortality of young following OP exposure in the field. The inconspicuousness of nests and young, the potential for young birds of affected adults to be great distances from the source of contamination (White et al. 1979), and the remoteness of many applications probably account for the low number of incidents reported.

The long term effects of OP-related mortality on wildlife populations are not known. To our knowledge, no permanent declines in overall populations have been attributed to their use. However, the mortality of about 400 raptors (species with reproductive potentials lower than those of most birds) following the use of monocrotophos (Mendelssohn and Paz 1977) may have significantly affected populations of some of the species. Use of carbophenothion as a seed treatment was banned in Scotland because its use was believed to threaten populations of wintering geese (Stanley and Bunyan 1979). The possible effects of famphur (applied to cattle to control grubs and lice) on declining populations of black-billed magpies *(Pica pica)* in the western United States are currently being investigated (C. J. Henny, pers. comm.).

Whenever pesticides are applied to wildlife habitat, mortality of wildlife may occur. Testing of pesticides before registration cannot evaluate all of the potential environmental-pesticide-wildlife interactions. However, precautions should be taken to minimize the mortality of wildlife following OP applications. This can be done by reducing the potential for contact between the pesticide and wildlife (e.g., timing of applications) and using OPs that are effective pesticides but of low toxicity to wildlife.

Sublethal Effects

In birds and mammals, OP exposure is frequently associated with loss of body weight (Costa and Murphy 1982, Grue 1982), which appears to be due to pesticide-induced anorexia (Grue 1982). Weight losses may be severe; losses of up to 40 percent have been reported in adult birds (Stromborg 1981, Grue 1982).

Reductions in food consumption following OP exposure may affect reproduction in birds and mammals. Egg production was significantly inhibited in ring-necked pheasants *(Phasianus colchicus)* (Stromborg 1977) and bobwhite quail *(Colinus virginianus)* (Stromborg 1981) fed diets containing diazinon, due in part to OP-induced anorexia. Similarly, reproductive performance was altered in laboratory mice given daily oral dosages of diazinon. Pregnant mice exposed to this OP gained less weight during gestation and had reduced litter sizes compared with controls (Spyker and Avery 1977).

Loss of body weight following OP exposure may result in a greater susceptibility of affected animals to environmental stressors. This may be particularly important to small birds and mammals with high metabolic rates (e.g., Pope and Ward 1972) and fledgling altricial birds. Growth of altricial nestlings may be depressed following OP exposure, and weights at fledging may be lower than normal (Pearce and Busby 1980, Powell and Gray 1980). The implications of low fledging weights due to OP exposure are not known, but for birds not exposed to contaminants, low fledging weights have been associated with a decrease in post-fledging survival (Perrins 1965, Smith 1967, Loman 1977).

Sublethal effects of OP exposure other than anorexia may also affect reproduction. Observed alterations in the production and structure of song by breeding birds following OP exposure (Forsyth 1980, Grue and Shipley 1981) may affect territoriality and courtship. OP-induced reductions in visual acuity (Plestina and Piukovic-Plestina 1978), vigilance (Levin and Rodnitzky 1976), and food-seeking behavior (Adams 1977) may affect the ability of adults to care for or protect their young. Adult laughing gulls orally dosed with parathion spent less time incubating their eggs than controls (D. H. White, C. A. Mitchell, and E. F. Hill, unpubl. ms.). Similarly, adult female starlings *(Sturnus vulgaris)* orally dosed with dicrotophos made fewer trips to feed their young and remained away from their nests for longer periods of time than controls (Grue et al. 1982b). Sublethal OP exposure has also been shown to alter hormone levels in birds and mammals (Rattner et al. 1982a,b); subsequent reproductive effects appear to be in addition to those associated with OP-induced reductions in food consumption (Stromborg 1981, Rattner et al. 1982a).

In addition to OP-induced reductions in food consumption, other sublethal effects of OPs may reduce the survival of wildlife. Exposure to OPs has been shown to cause hypothermia in birds (B. A. Rattner and J. C. Franson, unpubl. data) and mammals (Chattopadhyay et al. 1982). Studies by Street and Sharma (1975) indicate that OP exposure may reduce the resistance and immune response of exposed animals. OP exposure has also been shown to affect learning in birds (J. F. Kreitzer, unpubl. ms.) and laboratory rodents (Russell 1969, Bignami et al. 1975). A major effect of OP exposure on learning appears to be a reduction in the speed of extinction of a conditioned response, possibly by suppression of competing responses needed for the solution of new problems (Russell 1969). Such an effect could result in the appearance of stereotyped behavioral patterns resistant to changes in an organism's environment which could reduce survival. OP-induced reductions in visual acuity, vigilance, auditory detection (Reischl et al. 1975), coordination, and endurance may increase the potential for predation of sublethally exposed animals.

Predatory birds appear to be attracted to areas treated with OPs (Zinkl et al. 1979, L. R. DeWeese, L. C. McEwen, R. D. Deblinger, and L. A. Settimi, unpubl. ms.). McEwen and Brown (1966) suggested that the loss of radio-tagged sharp-tailed grouse *(Tympanuchus phasianellus)* to predators was increased following a sublethal dose of malathion. Although these observations appear to be the only data suggesting increased vulnerability of wildlife to predation following sublethal OP exposure, grass shrimp *(Palaemonetes pugio)* exposed to sublethal concentrations of parathion or methyl parathion were more vulnerable to predation by gulf killifish *(Fundulus grandis)* due to an increase in spontaneous activity, which made them more easily detected by the predator, and a reduction in endurance once pursued (Farr 1977, 1978).

The relationship between brain ChE inhibition and the onset and duration of direct toxic effects appears to be complex (Russell 1969, Clark 1971, Bignami et al. 1975). With some exceptions (e.g., Kurtz 1977), it appears that following acute OP exposure the magnitude of neurological symptoms and behavioral responses are inversely related to brain ChE activity and directly related to brain acetylcholine levels once brain ChE activity has been depressed 40 to 60 percent. This generalization appears to apply only to a relatively short period of time after an animal's initial OP dose, regardless of the potential duration of exposure. If an animal survives the initial dose, it may become symptom-free within a few hours or days even though brain ChE levels remain significantly depressed or continue to decrease (Bignami et al. 1975, Costa et al. 1982). In other cases (Keith and Mulla 1966, Grue 1982), neurological and behavioral effects may be apparent as long as an animal is exposed, followed by rapid recovery after exposure ceases. Or effects may persist for relatively long periods of time (weeks or months) even though brain ChE and acetylcholine levels have returned to normal (Johnson 1975, Duffy et al. 1979).

Although results of laboratory and controlled-field studies suggest that sublethal OP exposure may reduce reproductive success or survival, few studies have examined the sublethal effects of OPs on free-living wildlife following operational OP applications. Most studies have attempted to assess the impacts of OP applications indirectly by quantifying exposure (brain ChE inhibition [e.g., Westlake et al. 1980, Zinkl et al. 1980, Busby et al. 1981, 1983, Hamilton et al. 1981a]) or comparing pre- and post-spray counts of live or dead individuals (e.g., Takken et al. 1978, Bart 1979, Pearce et al. 1979, Tabata and Kitahara 1980). Results of these studies are difficult to interpret because of (1) the complex relationship between brain ChE inhibition and the onset and duration of neurological and behavioral effects, or (2) the many factors that may confound the interpretation of pre- and post-spray census data (Grue and Shipley 1981). Of the studies that have examined the sublethal effects of OPs on free-living wildlife (Jackson 1952, Black and Zorb 1965, Giles 1970, Robel et al. 1972, Caslick and Cutright 1973, Buckner and McLeod 1975, Stehn and Stone 1975, Varty 1976, DeWeese et al. 1979, Richmond et al. 1979, Pearce and Busby 1980), few have demonstrated effects on survival or reproduction. The growth of nestling white-throated sparrows in areas treated with fenitrothion to control spruce budworm was depressed, and young fledged at lower weights than controls (Pearce and Busby 1980). Buckner and McLeod (1975) reported reduced reproduction and survival of small mammals in forests treated with fenitrothion. Applications of 0.4 pounds per acre (0.5 kg/ha) resulted in reduced numbers of juveniles, numbers of adults were reduced at 0.9 pounds per acre (1.0 kg/ha), and above 1.3 pounds per acre (1.5 kg/ha) there was a pause of one cycle in the seasonal reproductive pattern. Recovery of reproduction and population levels occurred within the year of treatment, and no effects were detected the following year. Application of malathion at 2 pounds per acre (2.2 kg/ha) resulted in a population decline of 20 to 45 percent for white-footed mice *(Peromyscus leucopus)* and 55 percent for chipmunks *(Tamias striatus)* (Giles 1970). Reductions in the numbers of both species were apparently due to reduced productivity of adults or survival of young, and not mortality of adults. In all of these studies, indirect effects of the OP applications (e.g., pesticide-induced reductions in parental care or food abundance) may have contributed to the observed results.

Indirect Effects

The reproductive strategies of many species of wildlife have evolved to synchronize reproduction with prey abundance. For many wildlife species the reproductive season corresponds to peaks in insect populations. Several studies have documented significant declines in insect populations following pesticide applications (e.g., Barrett and Darnell 1967, Barrett 1968, Varty and Titus 1974). Applications of OPs could, therefore, interfere with reproduction by depressing insect abundance.

The effects of pesticide-induced reductions in insect abundance on the behavior, survival, and reproductive success of wildlife are poorly known. Keith and Flickinger (1965), McEwen et al. (1965, 1972), Barrett and Darnell (1967), Giles (1970), Doane and Schaefer (1971), Moulding (1976), and Bart (1979) have suggested that birds and small mammals emigrate from pesticide-treated areas due to reductions in insect abundance. The effects of such movement on breeding birds may be severe. Abandonment of nests may mean reduced reproductive success as second nesting attempts are usually less successful (Lack 1970:32). For wildlife species that remain in treated areas, reductions in insect abundance may result in reduced survival of young. Survival of grey partridge *(Perdix perdix)* chicks in agricultural areas was directly related to pesticide-induced reductions in insect abundance (Potts 1977). In contrast, reproductive success of red-winged blackbirds *(Agelaius phoeniceus)* was not affected by a 50 percent reduction in the principal food of nestlings following the application of fenthion (G. V. N. Powell, unpubl. ms.). However, as noted by Powell, the abundance of insects may have been above average during his study and insecticide-induced reductions in prey could have a pronounced effect when food resources are naturally low.

The direct toxic effect of OPs on adults may also indirectly reduce reproductive success. Decreased nest attentiveness of adult laughing gulls due to OP-induced mortality or changes in behavior resulted in the mortality of gull chicks (White et al. 1979). Similarly, OP-dosed female starlings made fewer trips to feed their young and remained away from their nests for longer periods of time than controls (Grue et al. 1982b). The young of the OP-dosed females lost significantly more weight than those of controls.

Factors Affecting Vulnerability

Many factors may increase the vulnerability of wildlife to OPs (see Buttiker 1961, Tucker and Leitzke 1979). Species sensitivity, physiological condition, behavioral traits, and the timing, rate and frequency of applications, and the chemical formulation are important.

The sensitivity of wildlife to OP exposure varies between chemicals and species. Generally, the sensitivity of birds is > mammals > amphibians (Gaines 1969, Tucker and Crabtree 1970, Schafer 1972, Schafer and Cunningham 1972, Hudson et al. 1979, Schafer and Brunton 1979, Kenaga 1979, Cholakis et al. 1981). The sensitivity of reptiles appears to be more similar to that of birds and mammals than other poikilothermic vertebrates (Hall and Clark 1982).

Route of exposure, sex, age, diet, and environmental conditions may also affect sensitivity. In birds and mammals, most OPs are more toxic when given orally than percutaneously (Gaines 1969, Hudson et al. 1972). In mammals, females appear to be more sensitive to OPs than males (Gaines 1969); similar differences have not been documented in other wildlife groups. Young mammals (Brodeur and DuBois 1967, Benke and Murphy 1975) and altricial birds (C. E. Grue and B. K. Shipley, unpubl. ms.) appear to be more sensitive to OP exposure than adults. This relationship is more variable in young precocial birds exposed to OPs (Hudson et al. 1972). Avian embryos are very sensitive to some OPs. External exposure of mallard eggs to less than twice the normal field application rates of naled and parathion resulted in mortality when the pesticides were dissolved in a nontoxic oil vehicle to simulate the use of a petroleum carrier (Hoffman and Eastin 1981, D. J. Hoffman and P. H. Albers, unpubl. ms.). Dietary deficiencies (Boyd et al. 1972) and cold stress (Chattopadhyay et al. 1982) also increase the toxicity of OPs.

Body size and physiological condition also may affect the vulnerability of wildlife to OP exposure. Small birds and mammals may be more susceptible than their larger counterparts because their high metabolic rates require them to ingest greater quantities of contaminated food per unit body weight or make them less tolerant of OP-induced anorexia (Hill 1972, Pope and Ward 1972, Grue 1982). Poor physiological condition may increase these effects. The dietary toxicity of dicrotophos to common grackles *(Quiscalus quiscula)* increased eight-fold between May and August and was associated with a decrease in fat reserves following post-nuptial molt (Grue 1982). The two most severe incidents of passerine mortality following OP applications have involved migrants (Stevenson 1972, Seabloom et al. 1973), birds presumably with poor fat reserves or high energy needs. Although captive birds may avoid OP-treated diets when untreated food is available (Hill 1972, Bennett and Prince 1981), environmental, behavioral, and physiological factors may force wildlife to ingest lethal quantities of contaminated food before a conditioned aversion is formed.

Vulnerability is also influenced by behavioral traits in relation to the habitat type treated, form of the pesticide applied, and the target species. Behaviors that congregate wildlife within treated habitats appear to be those associated with the largest OP-related die-offs (e.g., Stevenson 1972, Seabloom et al. 1973, White et al. 1982a,b). Foraging habits are also important. The potential hazards of OPs appear to be greatest for the wildlife species whose foraging habits include the treated substrate or the target organisms. For example, waterfowl are especially vulnerable to OP applications on turf or emergent small grain crops (Stone 1979, White et al. 1982a,b) that constitute a large part of their normal diet. Wilson's phalaropes *(Phalaropus tricolor)* are more susceptible than some bird species to applications of fenthion within wetlands, possibly because their aquatic foraging increases their exposure to the OP (L. R. DeWeese, L. C. McEwen, L. A. Settimi, and R. D. Deblinger, unpubl. ms.). Mortality of black-billed magpies following application of famphur to cattle appears to be due to the birds' habits of foraging on the backs of cattle (Felton et al. 1981, Hanson and Howell 1981). Birds that forage or nest within the canopy appear to be those most exposed to and affected by OP applications within forested areas (Pearce et al. 1979, DeWeese et al. 1979).

Characteristics of OP applications other than the form of the pesticide may also affect vulnerability of wildlife. OPs are frequently applied in the morning when weather conditions are optimum for treatment. Unfortunately, the activity of many wildlife species is also greatest at this time. Pearce (1971) reported that the hazards of fenitrothion to forest birds were reduced when spraying took place during the late evening, when most forest birds are relatively inactive. Although the relationship between application rate and exposure is well established, other factors such as the pesticide delivery system may affect the evenness of the application and thus the exposure of wildlife (Price 1977). Multiple applications of OPs or OPs and other pesticides may prolong the effects of pesticide applications and increase

(Murphy and Cheever 1968) or decrease (Menzer 1970, Gordon et al. 1978) the sensitivity of wildlife to subsequent pesticide exposure. The vulnerability of wildlife to OPs may also vary with the pesticide formulation. Birds within wet meadows sprayed with fenthion were more vulnerable to the pesticide when it was mixed with diesel oil instead of water (L. R. DeWeese, L. C. McEwen, R. D. Deblinger, and L. A. Settimi, unpubl. ms.).

Research Needs and Methods

Laboratory and controlled-field studies have shown that OP exposure may affect wildlife in many ways, but the extent to which these effects alter reproduction and survival in free-living populations is virtually unknown. Future research should determine (1) the extent of wildlife mortality following field applications of the most toxic and widely used OPs; (2) the impacts of OP exposure on the reproduction and survival of free-living wildlife, (3) the interactions among OPs, and between OPs and other classes of pesticides; (4) the residues and persistence of OPs in wildlife foods following field applications, and (5) the best techniques for assessing the impacts of OPs.

A combination of laboratory, controlled-field, and field methodologies will be needed to address these research needs (see Kenaga 1982). Laboratory studies will continue to provide data necessary for interpreting events in the field. Protocols that better simulate natural activity patterns and environmental stressors are needed to help extrapolate these data to the field. In addition, full-term reproductive tests with captive wildlife species need to be conducted. Although several laboratory studies have assessed the effects of OP exposure on the reproduction of galliforms (Gough et al. 1967, Sherman et al. 1971, Stromborg 1981, Rattner et al. 1982a), we are aware of only one laboratory study (J. C. Franson, J. W. Spann, G. H. Heinz, C. Bunck, and T. Lamont, unpubl. ms.) that has examined the effects of an OP on the reproduction of non-galliform birds. Laboratory studies that examine a variety of physiological and behavioral parameters in adult birds and wild mammals and their young are needed.

Controlled-field studies help bridge the gap between laboratory and field studies (Grue et al. 1982b). This approach also facilitates the comparison of the responses of captive and free-living wildlife to OPs (Grue et al. 1982a) and simultaneously the extrapolation of results of laboratory studies to the field. Colonial and cavity nesting species may be particularly suited for these studies because adequate sample sizes are easily obtained. The use of radio telemetry in field studies may facilitate monitoring the responses of free-living wildlife following OP exposure.

Field studies that assess mortality or other effects following OP applications are also needed. Previous field studies have concentrated on the effects of OP applications on range and forest wildlife. Generally, the OPs used in these habitats are less toxic than those recommended for use in agricultural lands and total OP use on range and forest lands probably represents only a small portion of the total OP use in North America. The effects of OP applications on wildlife inhabiting farmlands or adjacent habitats need to be investigated. The sole use of census procedures that are dependent on visual or auditory cues or ChE measurements to assess the impacts of OP applications on wildlife should be avoided because of potential difficulties in interpreting results. Measurements of ChE activity and residue analyses of food items should be included as measures of exposure in studies that attempt to quantify the direct and indirect effects of OP applications on reproduction and survival. The collection of data on ChE activity and the effects associated with different levels of inhibition may, in the future, provide a basis for predicting the impacts of these chemicals based on average levels of brain ChE inhibition in exposed wildlife populations (e.g., see Tucker and Leitzke 1979, Tipton et al. 1980).

Conclusions

Generalizations about the effects of OPs on wildlife populations appear premature; the data presently available are inadequate. Available data do indicate that (1) morality of wildlife following OP applications does occur, (2) sublethal OP exposure can affect physiological and behavioral characteristics that may be necessary for survival and reproduction, and (3) indirect effects of OP applications have the potential to alter the distribution and abundance of wildlife species. The extent to which these effects may alter recruitment and population size is virtually unknown. Additional research is needed to assess adequately these impacts.

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A Physiological Model For Bioeffects Monitoring

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There is increasing interest in bioeffects monitoring to complement monitoring carried out by measuring the residue levels of chemicals. Bioeffects monitoring can have the advantage that it demonstrates the degree of damage to the environment and can often be less expensive than chemical analysis. The ultimate purpose of monitoring bioeffects is to assess the state of health of the environment. In order to carry that out, it is necessary to correlate changes caused by other stresses such as food shortages and adverse climatic conditions.

The ideal system would be a bioeffect which gives a marked, reproducible change for a specific chemical or group of chemicals. The bioeffect should be related to a physiological process vital to the survival of the organism so that its biological significance is clear, and the effect should show a minimum of interspecies variation. Virtually all of these provisions cause difficulties as exemplified by the available assays. Some lack specific responses to different xenobiotics, while others are not clearly related to vital processes.

No single bioeffects monitoring system is going to give all the answers. If a bioeffect is highly specific—inhibition of deltaaminolevulinic acid dehydratase by lead—then information is obtained on only one element, but the change is readily correlated with pollutant levels. The inhibition of acetylcholinesterase activity is less specific, reflecting exposure to any of a wide range of organophosphates or carbamates, although differences in the spontaneous and chemically-induced reactivation can be used as a differential diagnosis between those two classes of chemicals (Martin et al. 1981). Analysis of AChE activity is much easier than chemical analysis, and the degree of inhibition can be related to the risk since the system being studied is vital to the organism.

Cytochrome P450 and the mixed function oxidase (MFO) system play an important role in the metabolism and subsequent excretion of lipophilic xenobiotics. The liver is an important site for xenobiotic oxidation as it possesses the capability to rapidly remove toxicants from the blood (Klaassen 1975). MFO systems are located in all organs, but because of the volume and variety of foreign compounds encountered in the environment, the liver MFO system has the highest detoxication activity and the broadest substrate specificity (Kappas and Alvares 1974). The MFO system oxidizes the material to a more hydrophilic form which in turn may be conjugated by a second set of enzymes and excreted.

In this work, the effects of individual and combined xenobiotics on the hepatic MFO system were examined. A total performance index has been defined and its physiological significance examined in terms of meaningful comparison of risk as functions of dose, time of exposure, species, and other exogenous conditions.

Development of a Physiological Model

The progress of a xenobiotic compound through an animal from the instant of contact to eventual elimination is characterized by a sequence of symptoms or responses that can be divided into three principal types. The most readily recognized is a failure or loss of normal efficiency in susceptible biochemical subsystems that could lead to pathological conditions. In some systems such loss of efficiency is followed by compensatory changes through control enzymes that return metabolite concentrations to apparently normal levels. This pseudonormal response is often accompanied by unusual levels of secondary metabolites, for example, nonheme porphyrins in lead intoxication (Gaertner and Hollebone 1983). The third type of response is a defensive induction of new metabolic capacity, capable of chemically altering the xenobiotic in preparation for excretion.

Each of these responses makes a contribution to the total risk (R_T) from exposure to the substance. The responses can be quantified as individual hazards (H_i), each defined by a dose-time response curve in terms of response per unit dose-time. The failure hazards (H_F) would contribute positively to the total risk, the compensatory H_C would make little overall contribution and the defensive reaction (H_D) would contribute negatively, decreasing the total risk. For all different types of exposure(E_j) in units of dose, the net total risk in units of response becomes

$$R_T = (\sum_F H_F + \sum_C H_C + \sum_D H_D)\,(\sum_j E_j) \qquad (1)$$

The defensive reactions are very sensitive bioeffects monitors because they are found in all parts of the body, and they usually respond vigorously and very quickly to initial contact with xenobiotics. They differ from the failure and compensatory responses in that genetically controlled adaption to both the structure and the chemical reactivity of the xenobiotic may occur. Within minutes to a few hours, specific metabolic activity may be elevated ten or more times above control levels and maintained for several days.

The mixed-function oxidase (MFO) enzyme system is an example of defensive systems. It is an oxidative protein supported in the endoplasmic reticulum of cells, particularly in skin, lung, gastrointestinal tract, and liver. On contact or ingestion of a hydrophobic substance, the enzyme is rapidly induced, and the heme at the active site metabolizes oxygen to produce hydroxylated derivatives of the initial compound. This increases the water solubility and promotes transport by the circulatory system. Usually, the oxidized material enters the liver, where second and subsequent stages of hydroxylation permit conjugation and bilary or renal excretion (Figure 1). Thus, the original compound may pass through several biotransformation steps, producing at each stage new compounds which may be toxic in their own right.

A bioeffects monitoring protocol can be designed using the hepatic MFO response, even though the liver is not the point of initial contact. While the response may be to derivative rather than primary compounds, the response is vigorous and reproducible when a single route of contact, such as ingestion with food, is employed.

The response consists of at least four components. Increases are observed in

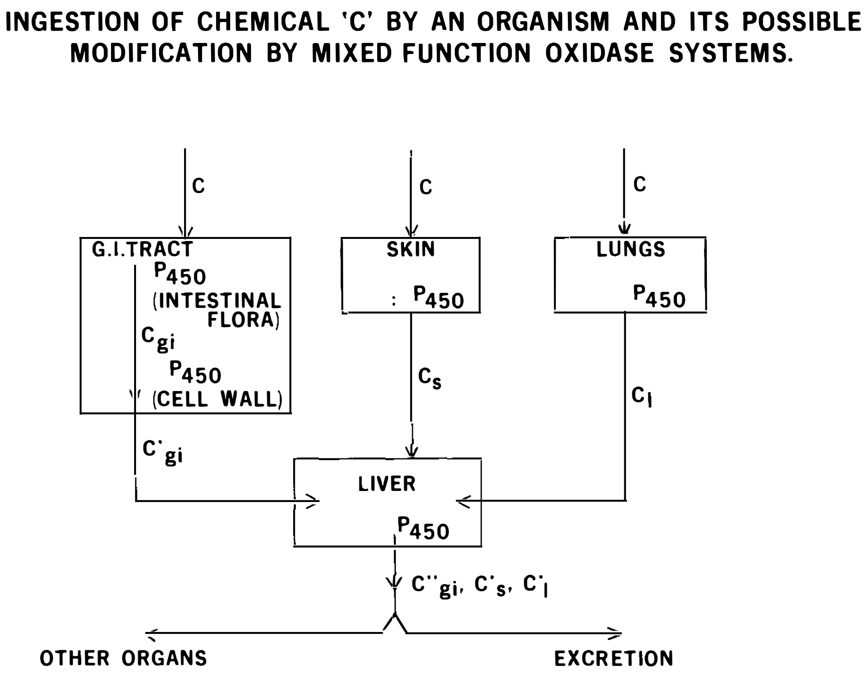

Figure 1. Possible ingestion routes and biotranformations of xenobiotics by the multifunction oxidase systems.

the specific activity of the active site, in the concentration of active sites in the support protein, in the amount of protein of each cell devoted to MFO activity, and in the capacity to transport resources and metabolites in and out of the cell. These four changes can be assessed experimentally on the assumption that, in the short term, changes in liver weight represent essentially the changes in amounts of material involved in cell metabolism (Boersma et al. 1983). Each response amplifies the benefits of all others, and the total response is represented as a product of all four changes with respect to controls. The total response is referred to as the Total Hepatic Induction *(THI)* index.

$$THI_{exp} = \left(\frac{\text{Activity}}{[\text{P450}]}\right)\left(\frac{[\text{P450}]}{[\text{Microsomal Protein}]}\right)\left(\frac{[\text{Microsomal protein}]}{\text{Liver weight}}\right)\left(\frac{\text{Liver weight}}{\text{Animal weight}}\right) = \frac{\text{Activity}}{\text{Animal weight}} \quad (2)$$

in which

(Activity)	is the measured metabolic rate using a standardized test substrate.
[P450]	is the concentration of cytochrome P450 active site, measured spectroscopically.

[Protein]	is the concentration of support protein in microsomes, measured by the Lowry method.
(Liver weight)	is the weight of perfused, excised whole liver.

It has long been known that each factor is induced with exposure to xenobiotics. The *THI* index reflects the overall improvement in performance of the liver in metabolizing the xenobiotic in a fully consistent manner since all changes are expressed as unitless ratios to control behavior. There may be additional contributing factors, but these four appear to be most significant. Since total hepatic induction is defined, the performance of animals under different endogenous and exogenous conditions may be compared directly. Comparison of rats and doves (Brownlee et al. 1983) shows that the different contributions are induced to different extents in the two species under very similar sets of dose, time, and maintenance conditions. A comparison of a single component of the *THI* would yield very misleading data with respect to overall defensive capability; both species respond adequately to the toxic challenge but do so by very different mechanisms. In rats the challenge is met largely by increases in specific activity, while in the doves it is met by a small increase in activity, but proportionately larger increases in the remaining factors (equation 2).

For a complete understanding of MFO defensive response, the Total Induction indices for each organ encountered between contact and excretion would be required. In the absence of these data, the strong hepatic reaction may be a guide to the overall physiological response.

These induction indices are functions of both dose and time of exposure. The level of total induction for any pair of dose-time values appears on a dose-time response (DTR) surface. In Figure 2 the DTR surface for *THI* response to aromatic hydrocarbons is shown (Brownlee et al. 1983). Clearly, a given response value will appear as a contour on that surface. This value is useful as an indicator of animal health only if the history of exposure is sufficiently known to identify the relevant part of the DTR surface in a given situation.

Application of Model to Intoxication by 1,3,4-Trichlorobenzene and Lead

The behavior of the four principal contributions to the THI index and the index itself were examined at fixed dose as a function of time with doves exposed to two xenobiotics both separately and in combination.

Juvenile ring doves *(Streptopelia risoria)* were separated into 16 groups. Four groups, fed Purina chick chow, served as controls. Four groups had 38 ppm 1,3,4-trichlorobenzene (TCB) added to the diet, four had 100 ppm lead acetate (Pb), and the remaining four had TCB and Pb added at the same levels to their diet. One group from each treatment regime was sacrificed at 7, 14, 21 and 28 days. Blood samples were taken before sacrifice for measurement of heme production. The livers were removed, weighed, and MFO activity measured in the liver homogenates. Experimental details are given elsewhere (Brownlee et al 1983).

The behavior of the *THI* index for all three dosing experiments is shown in Figure 3. Individually, TCB and lead both stimulate induction of the MFO system, but the patterns of induction are quite different. TCB, in common with other organic xenobiotics, shows initial induction, a plateau, and a second stage of induction at three weeks. This has been observed in rats and is implicit in exper-

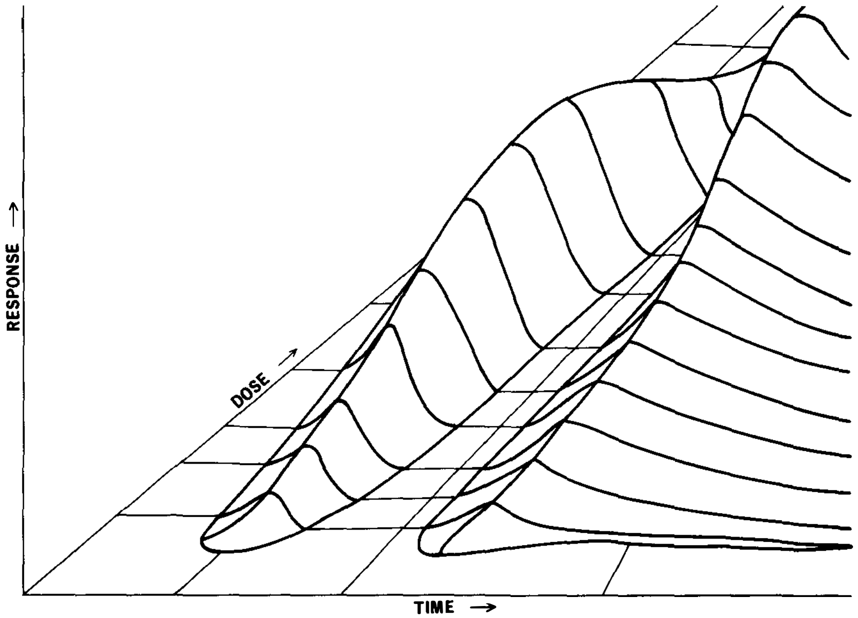

Figure 2. Dose-time response diagram for THI response to aromatic hydrocarbons.

iments on other species (Brownlee et al. 1983). The plateau at two weeks becomes a depletion back to control values in species in which the THI depends mostly on induction of the specific activity term. In the ring doves this effect is less important and the induction of the other three terms prevents collapse of the THI response at that time. In contrast, lead intoxication leads to a maximum in induction at two weeks at substantially lower overall levels. At four weeks, the levels return to those of the controls and the doves remained in apparent good health. This return to control levels was accompanied by the appearance, in the *blood serum,* of non-heme porphyrins. This implies that a compensatory increase in heme synthesis in the liver and other soft tissue had occurred, in addition to an adaptation in bone marrow evidenced by an increased, spectroscopically different erythrocytic, non-heme porphyrin.

Ring doves on the combined dose displayed a non-additive response. The response reaches half of the predicted value and retains a profile similar to TCB response rather than that obtained by adding the lead response. This evidence suggests that the action of the xenobiotics is competitive. The induction stimulated by TCB is apparently depressed by the presence of lead. Since non-heme and heme porphyrins begin to appear in the blood plasma after three weeks, it is possible that lead depresses the response by direct inhibition of heme synthesis, as is observed *in vitro* (Gaertner and Hollebone 1983).

The usefulness of this physiological model is more obvious if the behavior of its components is examined. Throughout this study, the specific activity, the concentration of adapted enzyme, and the concentration of protein all increased. How-

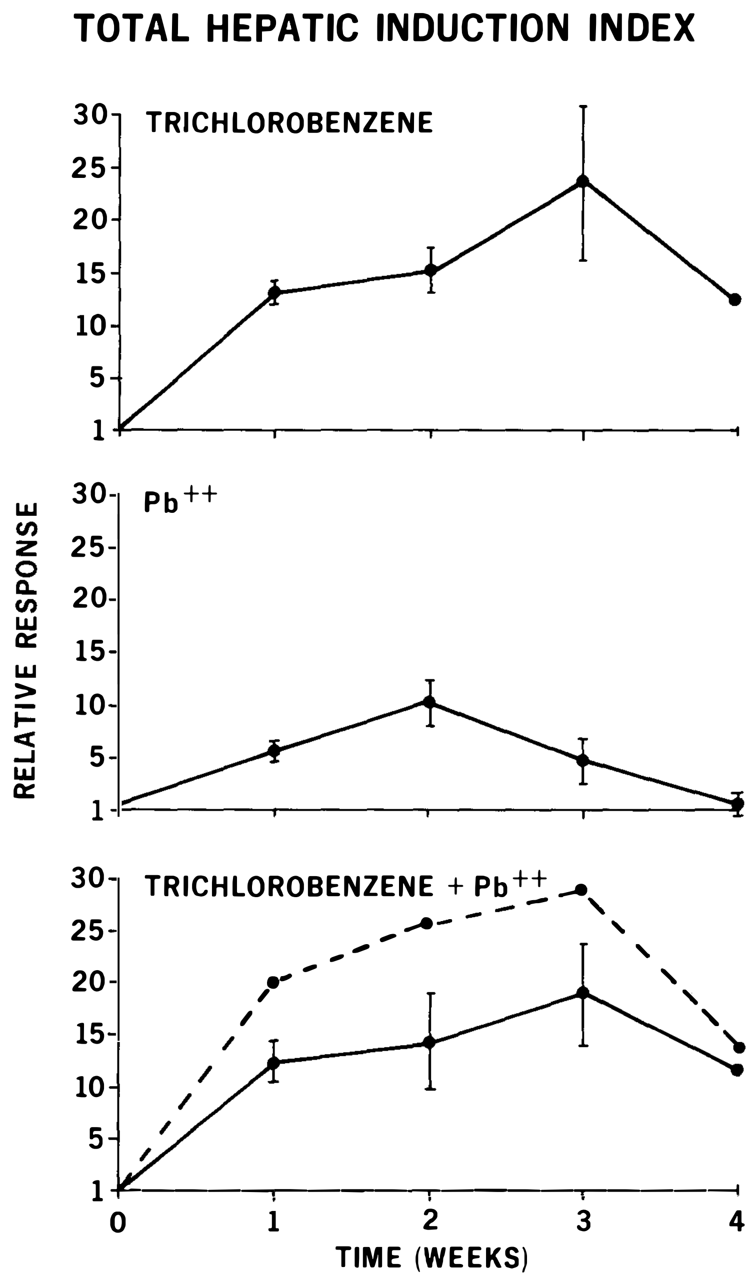

Figure 3. The Total Hepatic Induction index response for TCB, Pb and combined TCB + Pb diets. The broken line is the mathematic addition of the individual response to TCB and Pb, whereas the unbroken line is the response to the combined dose.

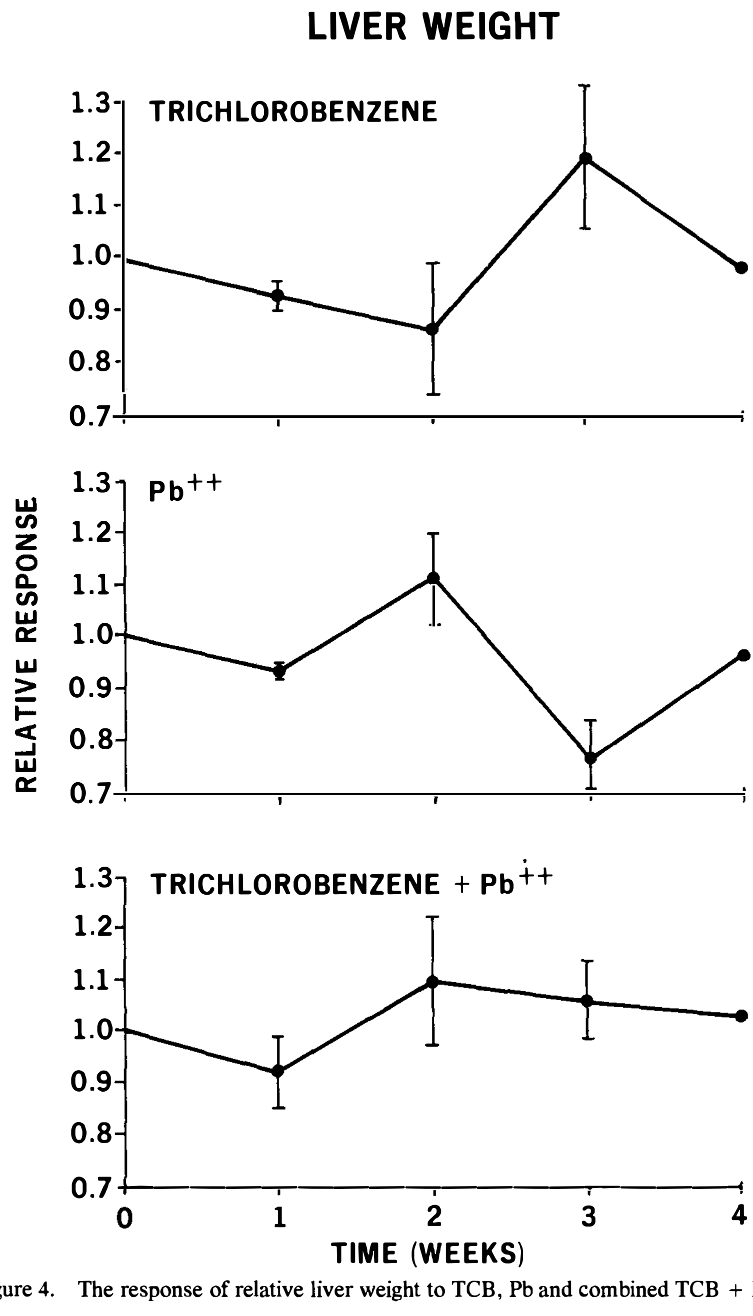

Figure 4. The response of relative liver weight to TCB, Pb and combined TCB + Pb diets.

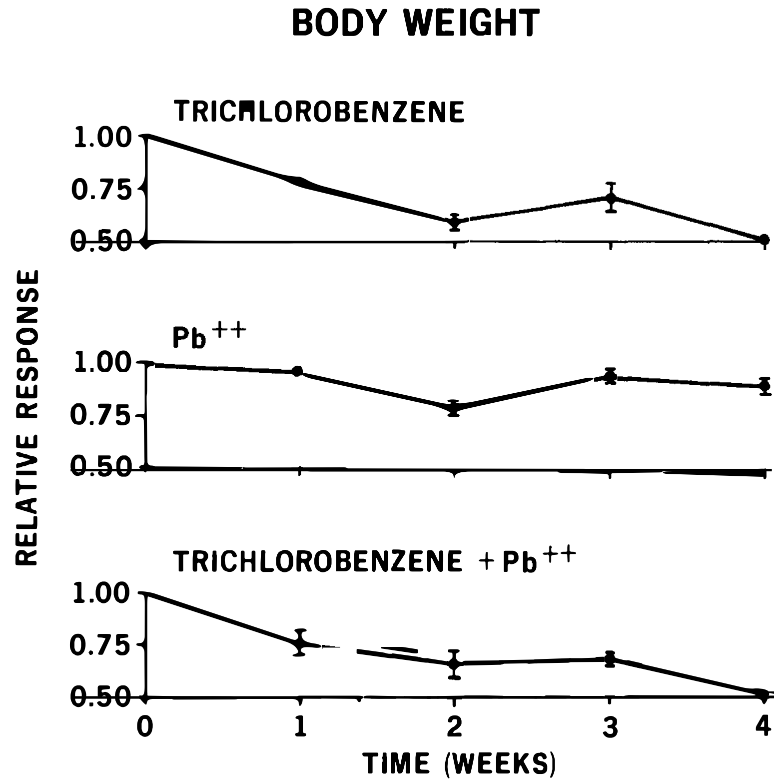

Figure 5. The response of relative body weight to TCB, Pb and combined TCB + Pb diets.

ever, the liver weight and the body weight either fluctuated or decreased (figures 4 and 5). With increasing exposure time, individual variation became substantial, but in both diets involving TCB the liver weight reached a maximum between two and three weeks and then declined. On the lead diet the weight fluctuated, but, after the appearance of non-heme blood bone porphyrins, it returned to control values.

On both TCB diets body weight relative to controls rapidly declined. In both cases a modest recovery was observed at three weeks, corresponding with the second phase of induction in specific activity. Subsequently, it declined further. On the lead diet, body weights remained near control.

For both effects the response was not linear with time, and the combined response was not a linear sum of the individual responses. More importantly, however, the induction of specific activity increased while body weight decreased, implying that the liver received preferential metabolic support in its detoxification function. Clearly then, the *THI* index does reflect physiologically relevant responses in both qualitative and, to a certain extent, quantitative respects. As such, it may become a useful monitoring technique for assaying the biological effects of environmental pollution.

However, it is also clear that a single, universal system does not exist and that a multifaceted approach will be needed. An understanding of the ways in which these tests are related and can complement each other will be of considerable importance in determining the practical usefulness of bioeffects monitoring in the field.

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Bald Eagles and Waterfowl: The Lead Shot Connection

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Introduction

Lead poisoning of waterfowl is well documented, with cases extending back almost a century (Grinnell 1894). Bellrose (1959) estimated that 2–3 percent of the nation's waterfowl die every year of lead poisoning. The problem is widespread and impacts non-waterfowl species as well. Such diverse species as rails (Wetmore 1919, Artmann and Martin 1975), godwits (Wetmore 1919, Quortrup and Shillinger 1941), ring-necked pheasants *(Phasianus colchicus)* (Hunter and Rosen 1965), mourning doves *(Zenaidura macroura)* (Locke and Bagley 1967), and bobwhite quail *(Colinus virginianus)* (McConnell 1967) have been reported as dying of lead poisoning. Lead poisoning also has been diagnosed in a number of captive raptors. Prairie falcons *(Falco mexicanus)* (Benson et al. 1974, Redig 1979), red-tailed hawks *(Buteo jamaicensis)* and a goshawk *(Accipiter gentilis)* (Redig 1979, Redig et al. 1980), Andean condors *(Vultur gryphus)* (Locke et al. 1969), and king vultures *(Sarcorhampus papa)* (Decker et al. 1979) have died of presumed lead poisoning associated with the ingestion of food items containing lead shot. Examples of free-ranging bald eagles *(Haliaeetus leucocephalus)* dying of lead poisoning also are in the literature (Mulhern et al. 1970, Jacobson et al. 1977, Kaiser et al. 1980). All of these bald eagles had liver lead concentrations above the 10 ppm level suggested by Pattee et al. (1981) as indicative of acute lead exposure; some also had lead shot in their digestive tracts. The reproductive potential and high turnover rates of many non-raptor species may reduce the impact of lead-related mortality on their populations, although this has not been studied extensively. Raptors, on the other hand, could be more readily impacted; their numbers and recruitment rates are generally low, magnifying the effects of individual losses. This is particularly true for bald eagles because populations are already depressed and only starting to recover from the pesticide abuses of the 1950s and 1960s. Bald eagles seem vulnerable because they readily utilize dead or crippled prey, which may contain lead shot or tissue-bound lead, and are closely associated with the same wetland complexes frequented by waterfowl; the probability of exposure is therefore increased.

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Lead Exposure in Eagles

The extent of the lead poisoning problem in eagles is unknown. J. F. Moore et al. (in preparation) analyzed livers from 650 dead bald eagles submitted between 1967 and 1982 to the Patuxent Wildlife Research Center, Laurel, Maryland and the National Wildlife Health Laboratory, Madison, Wisconsin. Forty-seven (7.2 percent) had liver lead levels and necropsy findings supporting a diagnosis of lead poisoning. For 168 bald eagles examined between 1975 and 1977 (Kaiser et al. 1980), lead poisoning (5.4 percent) ranked fourth behind shootings (17.9 percent), impact injuries (13.1 percent), and electrocutions (10.1 percent) and equaled the combined total of all other types of poisoning cases (6.0 percent) as cause of death. This suggests lead poisoning as an important mortality factor over the past 15 years.

One measure of exposure is blood lead. In experimental work done by Hoffman et al. (1981), bald eagle blood lead levels were below the detection limit (0.1 ppm, wet weight) in control eagles, averaged 0.8 ppm 24 hours after dosing with lead shot and 2.8 ppm 72 hours after dosage. They also reported levels in excess of 5 ppm in eagles immediately before death, whereas Reiser and Temple (1981) reported a mean blood lead level of 6.7 ppm to be associated with the onset of lead toxicosis in red-tailed hawks, rough-legged hawks *(Buteo lagopus)*, and a golden eagle *(Aquila chrysaetos)*. Based on the lead levels reported in the above studies, levels less than 0.1 ppm can be considered background in birds on uncontaminated feed. For ease of discussion, an additional two groups have been arbitrarily designated: 0.1–1.0 ppm and > 1.0 ppm. Of immature and adult eagles sampled over a broad geographic range (Table 1), 49 of 70 had detectible blood lead residues, and 27 percent from areas such as Minnesota had residues greater than 1 ppm, suggesting recent exposure to lead. Forty-eight of 106 nestling blood samples from Oregon and Minnesota also contained detectable blood lead levels (Table 1). The elevated blood lead levels reported from bald eagles suggest exposure to lead over much of their range. As a non-lethal means to evaluate exposure, blood lead is a valuable tool, though one cannot determine the source of the exposure or the length of time over which exposure occurred.

Lead Shot Versus Tissue-Bound Lead

A central issue in lead poisoning of bald eagles is whether the source of the lead is ingested in the form of shot, tissue-bound lead (contaminated tissue from lead-poisoned prey), or a combination of the two. Although the contribution of tissue-bound lead cannot be ignored, the data suggest that it only contributes to the problem and is unlikely to be the primary cause in most instances. Control diets of the eagles sampled by Hoffman et al. (1981) contained 0.7–3.7 ppm lead (wet weight) (files, PWRC), but resulted in blood lead levels below the detection limit (0.1 ppm). Franson et al. (1982) reported mean blood lead levels of 2.3 and 3.9 ppm (wet weight) in American kestrels *(Falco sparverius)* fed 10 and 50 ppm metallic lead in their diet for 5–7 months. Stendell (1980) fed American kestrels for 60 days on a diet of homogenized mallards (29.3 ppm lead, wet weight) that had died of lead shot poisoning, and there was no apparent effect and little elevation of liver lead levels. Pattee (in prep.) fed kestrels diets containing 50 ppm metallic lead for 5–7 months with no significant effects on survival and found tissue lead

Table 1. Blood lead levels (ppm, wet weight) in wild bald eagles sampled from 1978 to 1981.

State	Age	*N*	< 0.1 ppm	0.1–1.0 ppm	> 1.0 ppm	Reference
Minnesota	Immature	25	0	18	7	S. K. Hennes, in prep.
Minnesota	Nestling	24	0	24	0	Hennes and Frenzel, unpubl.
Minnesota	Unknown	5	0	4	1	P. Redig, in prep.[a]
Wisconsin	Unknown	11	1	8	2	"
South Dakota	Unknown	1	0	1	0	"
Oregon	Nestling	82	58	20	4	R. Frenzel, in prep.[b]
Oregon	Immature	5	2	3	0	"
Oregon	Adult	23	18	4	1	"

[a]University of Minnesota, St. Paul, Minn.
[b]Oregon State University, Corvallis, Ore.

levels in the dosed birds to be equivalent to those in many species of free-ranging birds from environments with no unusual sources of lead. Custer et al. (in prep.) fed kestrels a diet containing 136 ppm (wet weight) tissue-bound (biologically-incorporated) lead for 60 days with no apparent adverse effects and found 3.9 ppm (wet weight) lead in the livers of the kestrels. Conversely, 4 of the 5 bald eagles dosed with lead shot eventually died and exhibited elevated tissue lead levels (Pattee et al. 1981). Three of the 9 load-poisoned eagles reported by Kaiser et al. (1980) had lead shot in their stomachs, and Hennes (in prep.) found lead shot in the stomachs of 3 of 25 wild-trapped eagles caught in Minnesota. The previously reported elevated blood levels (Table 1) could be due (in whole or part) to the ingestion of tissue-bound lead, but some of the exposure seems related to the ingestion of shot.

Lead shot are frequently found in egested pellets collected at bald eagle roost sites. Dunstan (1974) found lead shot in 50–60 percent of the egested pellets examined from their midwestern study area, and Platt (1976) found 71 percent of the pellets from a Utah roost to contain shot. In recent studies involving the interactions between waterfowl and eagles, the occurrence of shot in egested pellets was 9 percent in Missouri (Griffin et al. 1980) and 11 percent in Minnesota (Hennes, in prep.). Redig et al. (1980) also implied that ingested shot were the primary cause of overt lead poisoning in the clinical cases they reported. It seems, therefore, that although tissue-bound lead contributes to the dietary lead burden, ingested lead shot is more important.

The presence of shot in egested pellets proves that not all exposure is fatal and that reexposure is probably common. It is continual reexposure to shot that constitutes the real hazard to eagles. Pattee et al. (1981) showed that continual exposure through repeated ingestion and elimination can lead to mortality. Most of the shot given to experimental eagles by Pattee et al. (1981) were regurgitated, but due to continual redosing, all 5 birds developed signs of lead toxicosis and 4 died. Sublethal exposure also could be critical, but is not as well researched. Pattee et al. (1981) reported that one eagle dosed with lead shot did not die, but did become blind and exhibited elevated brain lead levels. Reiser and Temple (1981) suggested that lead exposure could increase the susceptibility of raptors of secondary infections by a variety of organisms. The reproductive effects of chronic low-level lead exposure in eagles are unknown. However, American kestrels fed up to 50 ppm metallic lead in their diet exhibited normal shell thickness, fertility rates, and clutch sizes (Pattee, in prep.).

Source of the Lead Shot

Source of the shot is also an important question. The high prevalence of shot in the pellets of eagles reported by Platt (1976) evidently reflected the extensive use of hunter-killed and -crippled rabbits, whereas the incidence reported by Dunstan (1974) was attributed to eagles feeding on waterfowl. Waterfowl, especially Canada geese *(Branta canadensis)*, were important food sources to the eagles in the studies done by Griffin et al. (1982) in Missouri and Hennes (in prep.) in Minnesota. Waterfowl remains occurred in over 99 percent of the egested pellets in both studies and observations confirmed the significance of waterfowl, particularly dead and crippled waterfowl, as eagle food items in both areas.

Waterfowl are an important source of lead shot. Consumption by an eagle of a waterfowl gastrointestinal tract filled with shot could explain cases in which eagles are reported with numerous shot in their stomachs, but such incidents are probably rare. More probable is the ingestion of one or more shot that are embedded in the carcasses of unretrieved or sick game. The U.S. Fish and Wildlife Service (1975) estimates that 19 percent of the ducks and 15 percent of the geese harvested go unretrieved. These birds, along with those dying of lead-shot poisoning or any other cause, constitute a reservoir of shot to which eagles will be continually exposed. Sixty-six percent of the dead or moribund Canada geese found at a state-owned waterfowl refuge in Minnesota carried shot (Hennes, in prep.). Healthy birds also are a source; Elder (1950) reported that 28 percent of the mallards examined carried embedded shot, whereas Bellrose (1953) found 31 percent carried shot. Elder (1955) examined waterfowl of a number of species and reported shot incidence from a low of 1.4 percent in oldsquaws *(Clangula hyemalis)* to a high of 47 percent in Canada geese. More recently, 43 percent of the adult Canada geese from the Swan Lake National Wildlife Refuge, Missouri, were reported to carry embedded shot (Griffin et al. 1982), whereas 29 percent of the canvasbacks *(Aythya valisineria)* examined by Perry and Geissler (1980) carried shot. There was a general consensus by the authors that the larger the bird, the greater the prevalence of shot. Therefore, raptors feeding on waterfowl, regardless of the source, will be exposed to shot. Carcasses of larger birds, especially geese, will increase the probability of exposure because of increased probability of embedded shot being present.

The Waterfowl Connection

The recurring theme of bald eagles feeding on waterfowl and the similarity in habitat preferences in fall and winter all serve to bring together the necessary elements for lead poisoning: (1) Waterfowl concentrated in restricted areas due to limited suitable habitat or due to ideal conditions; (2) hunters attracted in these areas because of the waterfowl; (3) eagles concentrated because of the suitability of the habitat and because dead and crippled waterfowl provide a source of readily available food. The National Wildlife Federation's 1980 bald eagle survey (Figure 1) shows the location of January concentrations of 15 or more birds and represents 67 percent of the 12,340 eagles counted in the lower 48 states. Most of these concentrations of eagles are associated with rivers and other wetland environments. Based on a comparison of these areas with a map showing patterns of ownership, it can be determined that 70 percent of the areas are at least partially controlled by the Federal government. The importance of these findings can also be seen when one examines lead poisoning mortality over time. Based on unpublished data from the PWRC Chemistry Section files, it can be shown that 89 percent of the bald eagle lead poisoning cases occur between October and March, with the peak in January. The Patuxent Wildlife Research Center and the National Wildlife Health Laboratory are currently looking at this time-related mortality factor in greater detail.

Management Implications

Lead shot poses a significant hazard to bald eagles. Although mortality does not approach that associated with shootings and accidents, it may adversely affect

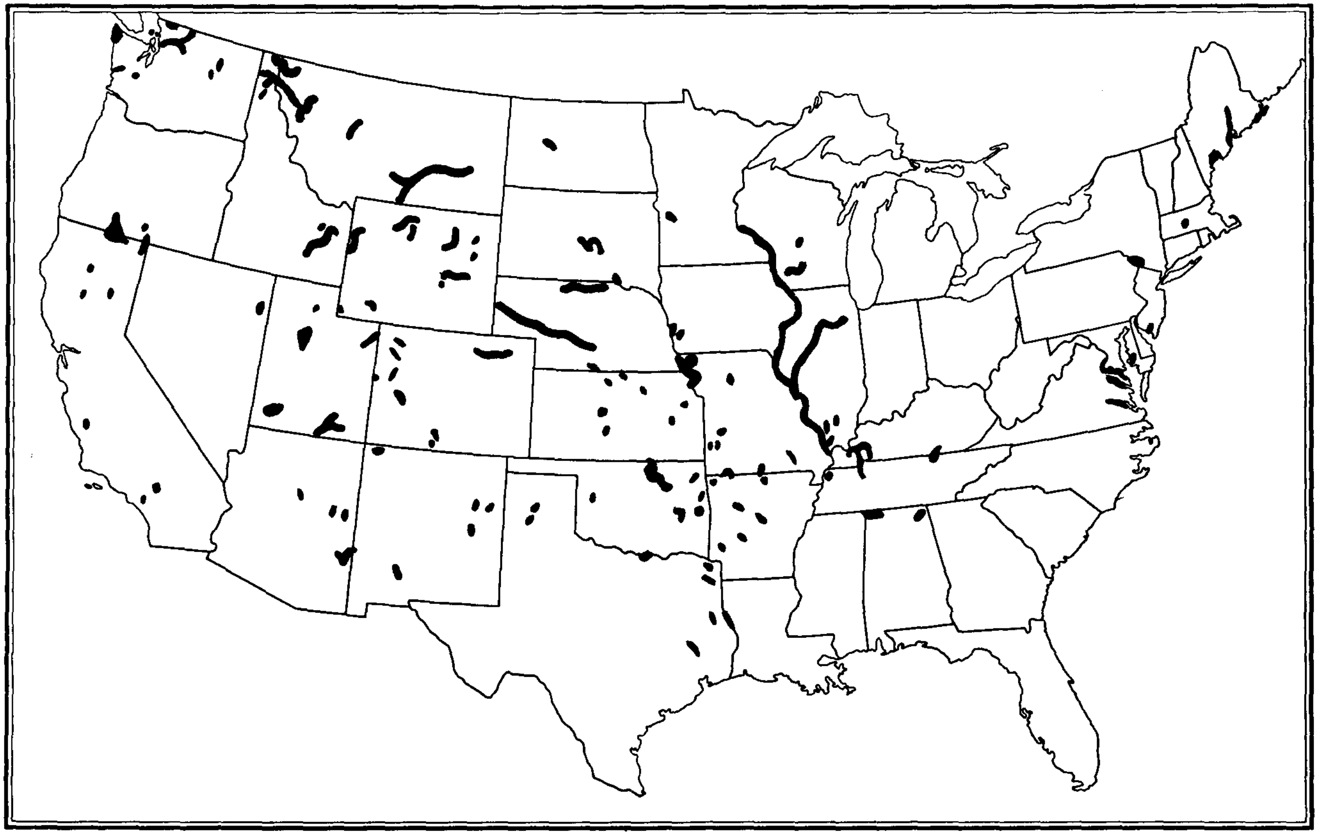

Figure 1. January bald eagle winter concentrations (15 or more birds) shown as darkened areas. (Courtesy of the National Wildlife Federation 1980 Midwinter bald eagle survey.)

already depleted populations during the critical winter period when other stresses also are at a peak. The actual impact of this mortality and of chronic low-level exposure on bald eagle populations is unknown, but warrants further investigation. The link between eagles and waterfowl is a strong one, and as the two become increasingly concentrated in smaller and smaller areas, the potential for lead shot problems exists. Managers should keep these facts in mind and evaluate the potential of their area for lead shot related mortality in bald eagles.

Acknowledgments

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Why is Environmental Contaminant Research Done by Wildlife Management Agencies?

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As the papers you have just heard attest, there is heavy involvement of both U.S. and Canadian wildlife management agencies in environmental contaminant research. You may ask, as visitors to our Research Center often do, why this work does not reside in the Environmental Protection Agency or its equivalents in other countries. The answer is a complicated one that tells us much about the scope and effects of wildlife contaminant research.

First and most important is mission. The resource management agencies are the only ones that have, as a primary responsibility, the management and protection of wildlife populations and their habitats. The regulatory agencies seek to protect human health through restriction of potentially harmful chemicals in the human environment. They may use data on wild animals supplied by wildlife agencies or by others, but their main focus remains the chemical and its ultimate effects on man. The wildlife management agencies alone look at animals, habitats, and chemicals as they coexist in the natural environment, and only they see the well-being of wildlife populations as the endpoint of their efforts.

Related to mission is capability; the human and material resources of wildlife management agencies are elements essential to the performance of the work. Simply put, they permit us to conduct wildlife contaminant research far better and more efficiently than it would be done by anyone else.

The thousands of wildlife species that must be managed have a bewildering complexity of biological characteristics and environmental requirements. The knowledge required for the protection of these species is extensive and far different from the intensive knowledge of one species or its surrogates required for the protection of human health. In fact, all the varied and specialized knowledge in the U.S. Fish and Wildlife Service, the Canadian Wildlife Service, and similar agencies is potentially available to our researchers working on contaminant problems. Only in these agencies could one expect to find, for example, experts on organophosphates and mourning doves under the same roof. Thus, in the wildlife agencies, though the biologists and chemists of the contaminant research program make up but a small part of the whole, they can draw on the considerable resources of the entire agencies to solve particular problems.

Another aspect of our unique capability to evaluate contaminant threats to wildlife comes from our geographic dispersion. Biologists assigned to refuges, field stations and their aggregates have designated responsibility for populations and habitats all over North America. The monitoring of wildlife and their populations that is part of the routine activity of wildlife managers can serve as an early warning system to alert us to contaminant-produced problems. Further, if more detailed investigations are necessary, these outposts can serve as staging areas for researchers.

Finally, the fact that most contaminant-wildlife expertise in both the United States and Canada resides in the resource management agencies has come to us through the historical development of centers of excellence such as the Patuxent Wildlife Research Center and its counterparts. The assembly of expert staff, costly equipment and facilities and, above all, collective professional wisdom takes many years and much patience. The institutions that have developed over decades are national assets of their respective countries. They are uniquely suited to protect the wildlife resources of North America from the threat of environmental contamination.

One example of how the whole system works is provided by the Fish and Wildlife Service's handling of contaminant-caused dieoffs of wildlife in the field. These episodes may be discovered first by Fish and Wildlife Service field biologists, or they may be brought to their attention by others. If chemical poisoning is suspected, these biologists collect specimens, including proper controls, according to a set of standard instructions. If disease is a possibility, they then ship them to our National Wildlife Health Laboratory in Madison, Wisconsin, where specialists perform necropsies and gather evidence that will tend to eliminate most causes of death other than chemical ones. Again according to a rigid protocol, specimens are shipped to Patuxent for further work. Brains are analyzed for acetylcholinesterase activity by techniques specifically adapted for wildlife species. Gastrointestinal tracts may be analyzed for traces of poisons, or various other tissues may be analyzed for residues of persistent contaminants such as mercury, lead, or organochlorines. Knowledge of those chemicals and use patterns likely to cause wildlife mortality often provides clues useful in chosing the lines of investigative attack. Finally, large or recurring dieoffs may trigger research directed to assess the impact or to elucidate the mechanism of lethality. Moreover, questions raised by field dieoffs have inspired a large proportion of the controlled research conducted at the Patuxent Center. This example illustrates how we have utilized a highly integrated system for dealing with the complex problems of wildlife toxicology. The process described represents the completed circle of interactions of research and management that lead to appropriate information and action; a contaminant problem is discovered, the circumstances contributing to the problem are investigated, the likelihood of population-level impacts are assessed, and research responsive to resource needs is designed and carried out. The information generated is ultimately made available as the basis of management decisions.

Migratory Bird Management: New Developments

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Estimating Autumn-Spring Waterfowl Nonhunting Mortality in North Missouri

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Waterfowl mortality due to hunting is complemented by nonhunting losses. Hunting mortality occurs primarily in the fall and early winter and is relatively well controlled and measurable. Post-season mail surveys of waterfowl hunters, field bag checks, and banding data have determined the magnitude, timing, and location of duck and goose harvest. In contrast, nonhunting losses resulting from disease, predation and weather occur throughout the year. Analyses of band recoveries have determined the relative magnitude of nonhunting losses, but the timing and importance of specific factors is poorly understood.

From a fall flight of about 80 million ducks, hunting mortality accounts for about 20 million birds lost annually, and nonhunting losses, primarily from disease, number an additional 20 million ducks (Bellrose 1978:64). Mortality rates vary among species and have been estimated from band recoveries. Anderson (1975) estimated an average annual mortality rate of 35 percent for adult mallard *(Anas platyrhynchos)* males, 43 percent for adult females, and 50 percent annual mortality for immature mallards. Hunting accounted for 40 to 50 percent of the annual losses. Band recoveries from Eastern Prairie Population (EPP) Canada geese *(Branta canadensis interior)* reflected annual mortality rates of 25 to 30 percent for adults and near 50 percent for immatures, respectively (Vaught and Kirsh 1966). Approximately 80 percent of annual losses are attributed to hunting (Babcock et al. 1978).

Studies concerning nonhunting mortality are complicated by the number of

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mortality factors involved and the transient behavior of waterfowl. Stout and Cornwell (1976) compiled information concerning nonhunting losses of more than 2 million waterfowl. The most important group of mortality factors, disease and poisons, were responsible for 87.7 percent of total losses, followed by mortality due to weather (7.4 percent), miscellaneous (3.7 percent), pollution (0.6 percent), predation (0.1 percent), and collisions (0.1 percent).

Similar to results from the study by Stout and Cornwell (1976), nonhunting mortality reported in Missouri has been predominated by disease and poisoning losses. Lead poisoning die-offs of a few hundred to 10,000 ducks and/or geese since 1948 (Humburg and Babcock 1982), 2,000 Canada goose losses to aspergilloses at Swan Lake NWR in 1966 (McDougle and Vaught 1968) and at least 7,000 ducks and geese lost to avian cholera at Squaw Creek NWR in 1964 (Vaught et al. 1967) reflect the nature of documented nonhunting mortality in Missouri. Increased inceidence of snow goose *(Chen caerulescens)* and Canada goose losses to avian cholera (Squaw Creek and Swan Lake Area files) and greater sensitization to lead poisoning justified investigation of the temporal occurrence, causes, and magnitude of nonhunting mortality on Missouri waterfowl areas. Studies were conducted during fall and winter, 1980 and 1981 on Swan Lake and Squaw Creek National Wildlife Refuges (NWR) and Fountain Grove Wildlife Management Area (WMA) to describe nonhunting waterfowl mortality in midwestern waterfowl concentration areas. Objectives of the cooperative, Missouri Department of Conservation and U.S. Fish and Wildlife Service studies were to (1) develop effective sampling methods to document autumn to spring nonhunting mortality, (2) determine the effects of scavenging, search efficiency, habitat and weather, and (3) determine temporal occurrence and relative importance of specific mortality factors.

Study Areas

Portions of Squaw Creek NWR, Swan Lake NWR and the Fountain Grove WMA refuges were selected for mortality surveys. Squaw Creek NWR is a 6,900 acre (2,793 ha) area located in northwest Missouri and Swan Lake NWR (10,970 acres (4,440 ha)) and Fountain Grove (6,180 acres [2,501 ha]) are located about seven miles (11.3 km) apart in north central Missouri. All study sites were proximate to hunting areas but varied in primary waterfowl species, population levels, history of disease problems, and non-toxic shot regulations.

Although no hunting was allowed on Squaw Creek NWR, waterfowl hunting on private wetlands and fields occurred on much of the area surrounding the Refuge. Snow geese and mallards predominated area waterfowl populations during the study. Peak snow goose populations during drought conditions in 1980 were less than 100,000, compared to populations between 100,000 and 300,000 during 1981 studies. Mallard numbers, 50,000–75,000 in 1980, were about one-half the levels reported in 1981. No regulations requiring steel shot use for waterfowl hunting near the refuge were in effect in 1980 and 1981. Estimated avian cholera losses of 100 to 1,800 snow geese and lead poisoning die-offs numbering 1,000 to 2,000 mallards occurred annually in the latter 1970s.

Controlled Canada goose hunting is conducted by the Missouri Department of Conservation on the perimeter of Swan Lake NWR and occurs on most private lands within five miles (8.0 km) of the Refuge. No duck hunting is allowed on Swan

Lake NWR. Canada goose populations near 100,000 birds accounted for about 75 percent of the waterfowl populations on the area. Snow geese (7,500 to 15,000 birds) and ducks, predominated by mallards (15,000 to 25,000 birds), complemented Canada goose populations. Steel shot was required on Swan Lake NWR, but not on private lands, during 1980 and 1981. Lead poisoning has been detected in some birds collected as "cripples" at Swan Lake, although few die-offs have been documented. Avian cholera has increased in incidence since the mid-1970s.

Duck and goose hunting is controlled by the Missouri Department of Conservation on Fountain Grove WMA. About 25 percent of the refuge area, where 1980 and 1981 mortality studies were conducted, is bordered by managed impoundments open to duck and goose hunting. Fountain Grove WMA waterfowl populations near 30,000 total birds were comprised of similar proportions of ducks (primarily mallards) and Canada geese until mid-to-late November. Canada goose numbers increased and numbers of mallards declined by late December. No steel shot restrictions were in effect in 1980. Steel shot was required on the area in 1981. Lead poisoning and avian cholera losses have been documented; however, no die-offs have been detected.

Methods

Techniques were designed during 1980 pilot studies and modified in 1981 to search portions of each study area. Four methods were developed and evaluated on the basis of numbers of waterfowl carcasses found per unit effort, proportions of carcasses suitable for necropsy, and whether data could be extrapolated to greater time or area.

One-Day Search

A one-day, post-hunting season search was conducted on each study area in 1980. Ten to 20 people searched approximately 5,000 acres (2,023 ha) at Swan Lake NWR, 575 acres (232 ha) at Fountain Grove WMA and 1,070 acres (433 ha) at Squaw Creek NWR as soon as the areas were frozen and most portions were accessible. Frozen areas in timber and emergent vegetation were searched intensively and open water areas scanned for evidence of mortality. Only intact birds, carcasses with both wings present or right wings from scavenged birds were counted. This eliminated any potential double-counting, but resulted in conservative estimates of loss. Dogs were used for retrieval of live birds.

Levee and Shoreline Search

In 1980, predetermined segments of shorelines, levees, or water/vegetation edge were searched twice each week at Squaw Creek NWR and once per week at Swan Lake NWR and Fountain Grove WMA. Total length of the segments, approximately 20 yards (18 m) wide, were 2.9 miles (4.7 km), 1.8 miles (2,9 km) and 2.9 miles (4.7 km) on Squaw Creek, Swan Lake and Fountain Grove, respectively. Carcasses found during searches were either marked or the right wing collected to avoid double-counting. A dog was used at Squaw Creek for all sampling.

Quadrat Sampling

Quadrats, ranging in size from 10 by 150 yards (9.1 by 137.1 m) at Squaw Creek and 20 by 200 yards (19.3 by 183 m) at Swan Lake and Fountain Grove, were randomly selected for semi-weekly search during 1980. At Swan Lake and Fountain Grove, 30 quadrats were searched twice per week separated by a three-day interval. Swan Lake quadrats were randomly selected from 752 quadrats in upland crop fields and from 86 quadrats located parallel to shorelines. Shoreline quadrats extended 10 yards into water and 10 yards onto land. Swan Lake sampling represented approximately 2,000 acres (809 ha) of uplands and 480 acres (194 ha) of shoreline habitats. Fountain Grove quadrats (283) represented about 230 acres (93 ha) of shorelines. Squaw Creek quadrats (30) were located primarily along open water/vegetation edges and represented 125–150 acres (51–61 ha) of edge habitat. The same 30 quadrats were searched semi-weekly throughout the 1980 field season. Quadrats at Squaw Creek were located perpendicular to shorelines and extended 30 yards (27 m) into open water and 120 yards (110 m) through inundated vegetation and onto land. Placement of Squaw Creek quadrats allowed determination of carcass distribution relative to water/vegetation edge. During 1980, intact carcasses were marked when found the first day of search and were collected for necropsy if they were present on the second day of weekly quadrat sampling. This was one attempt to determine scavenging rates. All other evidence of mortality was recorded and right wings collected or carcasses marked to avoid duplication.

Quadrat sampling on Swan Lake and Squaw Creek was modified and intensified during 1981. Swan Lake sampling was stratified by habitat type. Forty 40-by-100-yard (37 by 91 m) quadrats were searched semi-weekly along shorelines where numbers of carcasses found in 1980 were highest and most variable. Twenty quadrats 20 by 200 yards (18 by 183 m) in size were searched twice each week in upland areas. Sixty-five Squaw Creek quadrats 20 by 100 yards (18 by 91 m) in size were located parallel to water/vegetation edge. Different quadrats were searched weekly. All intact carcasses were collected in 1981 regardless of the day found because few birds left intact the first day of search in 1980 remained unscavenged three days later.

Spring quadrat sampling was conducted in 1982 on Swan Lake and Squaw Creek using the same procedure as the previous fall and winter.

Transect Sampling

An additional method, which involved sampling along predetermined transect lines (Burnham et al. 1980), was incorporated into the study at Fountain Grove WMA in 1981. Fifty-one transects, located 50 yards (46 m) apart were 310 to 1,020 yards (293 to 933 m) in length. Fifteen to 18 randomly selected transects were run each week and re-randomized after three-week intervals when all 51 transects had been covered. All observed evidence of mortality within 25 yards (23 m) of the transect line was recorded according to the perpendicular distance from the line and distance from the beginning of the transect. All intact carcasses were collected for necropsy. Use of a dog improved search effectiveness; however, these data were eliminated to meet assumptions of transect analysis. Four assumptions were critical to reliable results from transect sampling: (1) carcasses directly on the line were never missed, (2) birds did not move before detection and no birds were counted twice, (3) distances and angles to birds were measured exactly and (4) sightings were independent events (Burnham et al. 1980:14).

Variables Affecting Documentation of Mortality

In 1981, we attempted to quantify or describe the variables that affected our detection of waterfowl mortality. Characteristics of vegetation density, height, and type, distance to open water, weather, and carcass status (scavenged versus intact) were recorded for carcasses found during all methods of search. Specific studies were initiated to measure scavenging rates of search efficiency. To determine rates of carcass depredation, intact birds found away from areas of systematic search were observed to determine the number of days until disturbance. At Swan Lake, carcasses were observed until they disappeared or were partially eaten by scavengers. Periodic checks of intact carcasses at Squaw Creek were continued until all evidence of individual carcasses disappeared. Quadrat sampling efficiency was determined at Swan Lake by calculating the proportion of intact carcasses planted on quadrats that were detected when areas were searched.

Necropsy Analysis

Intact carcasses were examined by Missouri Department of Conservation personnel to determine cause of death. Valuable assistance was provided during this phase of the study by personnel of the U.S. Fish and Wildlife Service National Wildlife Health Laboratory, Madison, Wisconsin, and the University of Missouri Veterinary Diagnostic Laboratory, Columbia. Diagnosis of lead poisoning included analyses of livers by the University of Missouri Diagnostic Laboratory.

Results

Studies were initiated each year in late October or early November and continued until waterfowl migrated south from the areas in January. During the two-year study, 1,815 man-hours were required to search 185 miles (298 km) of transects, levees, or shoreline, 3,502 acres (1,417 ha) of quadrat sampling and 6,645 acres (2,689 ha) during one-day searches. Documented mortality included 1,915 birds at Swan Lake NWR, 867 at Fountain Grove WMA and 1,383 at Squaw Creek NWR. Canada geese were found most frequently (2,277), followed by snow geese (1,083), mallards (749), and other species (56). Primary species found during sampling varies among areas; however, mortality was proportional to each area's waterfowl population. Snow geese comprised 71.1 percent of the carcasses found at Squaw Creek, while mallards (23.5 percent) predominated remaining collections. Most of the carcasses found at Swan Lake were Canada geese (87.6 percent), followed by mallards (6.6 percent) and snow geese (5.1 percent). Birds found at Fountain Grove were primarily Canada geese (63.9 percent) and mallards (34.1 percent). There was considerable variation among the four search methods in the amount of mortality detected and the proportion of the carcasses that were intact. Of the total waterfowl mortality documented, 22.4 percent (934 of 4,165) was intact or alive birds; the remainder was found as feather piles, wings and bones, or partially eaten carcasses.

One-Day Search

The most efficient of the four methods, in terms of birds found, was a one-day search conducted at Swan Lake and Fountain Grove on 13–14 January 1981 and on 23 December 1980 at Squaw Creek. Coverage of 6,645 acres (2,689 ha) in 231 man-hours produced 1,710 intact or scavenged carcasses (Table 1). Despite the high rate of search efficiency (7.4 birds per hour), only 3.2 percent of carcasses were suitable for necropsy. Delaying the one-day searches until hunting seasons were over or until adequate ice conditions existed resulted in large numbers of carcasses found, but increased the number of depredated carcasses. One-day searches indicated significant waterfowl losses, but results could not be standardized.

Levee and Shoreline Search

Levee and shoreline searches were less efficient than one-day searches in terms of carcasses found per hour, but provided a higher proportion of intact carcasses,

Table 1. Results and effectiveness of search methods utilized at Squaw Creek, NWR, Swan Lake NWR, and Fountain Grove WMA in 1980.

	One day search	(Rate)[a]	Levees and shorelines	(Rate)	Quadrats	(Rate)	Other[b]
Swan Lake							
Carcasses	989	(9.3)	171	(2.7)	180	(0.69)	289
No. intact	36		14		7		93
Man-hours	106		624		260		—
Miles/acres	5,000 acres		22 miles[c]		595 acres[c]		—
(Km/ha)	(2,025 ha)		(35.4 km)		(241.0 ha)		
Fountain Grove							
Carcasses	330	(6.1)	301	(3.6)	82	(0.22)	31
No. intact	17		123		7		25
Man-hours	54		84.5		378		—
Miles/acres	575 acres		35 miles		228 acres		—
(Km/ha)	(232.8 ha)		(56.3 km)		(92.3 ha)		
Squaw Creek							
Carcasses	391	(5.5)	264	(4.1)	18	(0.16)	—
No. intact	3		172		7		—
Man-hours	71		65		60		—
Miles/acres	1,070 acres		34.5 miles		112 acres		—
(Km/ha)	(433.4 ha)		(55.5 km)		(45.4 ha)		
Total							
Carcasses	1,710	(7.4)	736	(3.5)	280	(0.40)	320
No. intact	56		309		21		118
Man-hours	231		211.9		698		—
Miles/acres	6,645 acres		91.5 miles		935 acres		—
(Km/ha)	(2,691.2 ha)		(14 7.2 km)		(378.7 ha)		

[a]Birds per hour.
[b]Unquantified levee and shoreline search conducted to supplement necropsy samples. Collections made throughout the season from areas of systematic search.
[c]Total quadrat acreage or levee/shoreline miles searched.

41.9 percent versus 3.2 percent (Table 1). Totals of 171 (2.7 birds per hour), 301 (3.6 birds per hour), and 264 (4.1 birds per hour) intact or depredated carcasses were collected at Swan Lake, Fountain Grove and Squaw Creek, respectively.

A portion of Squaw Creek mortality evidence, 174 of 264 carcasses, was found within two-days following an avian cholera die-off. A high proportion of these losses (67.8 percent) was intact and suitable for necropsy. Because of the efficiency of search for intact carcasses, supplemental, levee, and shoreline search was conducted away from systematic search areas at Swan Lake and Fountain Grove. A total of 320 carcasses, 36.9 percent necropsiable, was collected to increase the sample of necropsiable birds from the two areas.

Weekly searches of accessible shorelines, levees, and water/vegetation edges proved to be an efficient method to document mortality. More frequent search, 3–4 day interval, would have increased numbers of carcasses suitable for necropsy. Although levee and shoreline search could be standardized (number of carcasses per mile), data could not be extrapolated to totals lost on entire study areas.

Quadrat Sampling

The most intense, but least efficient, method tested in 1980 was quadrat sampling. Semi-weekly search of randomly selected quadrats at an average rate of 1.3 acres per hour resulted in documentation of 280 intact or depredated birds (Table 1). An average of 0.4 carcasses per hour was found and only 7.5 percent were suitable for necropsy.

Search of the same 30 quadrats throughout the six-week Squaw Creek study, 12 November through 21 December 1980, was an ineffective sampling method. Eighteen carcasses were found. Five carcasses, marked and left on quadrats until sampling again three days later, all disappeared. Perpendicular orientation to water/vegetation edge reduced the effective areas of the quadrats. Most (85 percent) of the carcasses collected at Squaw Creek in 1980 were found within 8 yards (7.3 m) of an open water/vegetation edge. This justified quadrat placement along open water edge during 1981 sampling.

Quadrat sampling at Swan Lake and Fountain Grove began on 10 November 1980 and continued until 1 February 1981. Total numbers of intact or depredated carcasses collected during twice-weekly searches of 30 quadrats ranged from 2 to 26 at Swan Lake and 2 to 19 at Fountain Grove. Average numbers of carcasses per quadrat were calculated for each week of quadrat sampling. Average weekly loss per quadrat was lowest during the first and last weeks of sampling and was greatest during the Canada goose hunting season at Swan Lake (1 November–9 January) and following duck season closure (15 December) at Fountain Grove. Weekly rates of loss as high as a bird per acre (0.4 ha) on the 838 Swan Lake quadrats and a bird per two acres (0.8 ha) on 283 Fountain Grove quadrats were estimated.

Greater sampling intensity improved results of quadrat searches during the 19 October 1981 to 10 January 1982 study. Of 990 waterfowl losses documented during 458.5 hours of quadrat search, 37.8 percent were carcasses suitable for necropsy (Table 2). Numbers of recorded losses ranged from 3 to 227 during weekly search of 65 Squaw Creek quadrats and at Swan Lake from 2 to 52 carcasses on 40 shoreline quadrats and 0 to 10 on 20 upland quadrats. Average numbers lost per

Table 2. Results and effectiveness of search methods utilized at Squaw Creek NWR, Swan Lake NWR, and Fountain Grove WMA during 1981 and spring, 1982.

			Quadrats							
			1981 Fall				1982 Spring			
	Transects	(Rate)[a]	Shoreline	(Rate)	Land	(Rate)	Shore	(Rate)	Land	(Rate)
Swan Lake										
Carcasses	—	—	255	(1.6)	28	(0.35)	3	(0.06)	0	(0)
No. intact	—		32		3		0		0	
Man-hours	—		160		80		53.3		26.7	
Miles/acres	—		793 acres[b]		397 acres		264 acres		132 acres	
(Km/ha)			(321.1 ha)		(160.7 ha)		(106.9 ha)		(53.5 ha)	
Fountain Grove										
Carcasses	123	(0.67)	—	—	—	—	—	—	—	—
No. intact	52		—		—		—		—	
Man-hours	184		—		—		—		—	
Miles/acres	82 miles		—		—		—		—	
(Km/ha)	(131.9 Km)									
Squaw Creek										
Carcasses	—	—	707	(3.24)	—	—	3	—	—	—
No. intact	—		339		—		3		—	
Man-hours	—		218.5		—		44.5		—	
Miles/acres	—		645 acres		—		186 acres		—	
(Km/ha)			(261.2 ha)				(75.3 ha)			
Total										
Carcasses	123	(0.67)	962	(2.54)	28	(0.35)	6	(0.06)	0	(0)
No. intact	52		371		3		3		0	
Man-hours	184		378.5		80		97.8		26.7	
Miles/acres	82		1,438 acres		397 acres		459 acres		132 acres	
(Km/ha)	(131.9 Km)		(582.3 ha)		(160.7 ha)		(182.2 ha)		(53.5 ha)	

[a]Birds per hour.
[b]Total quadrat acreage or transect miles searched.

week were estimated from quadrat sampling results and expanded to total mortality on 254 Squaw Creek quadrats and 334 Swan Lake shoreline and 685 upland quadrats.

The number of new carcasses found on quadrats during the second day of weekly searches indicated carcass accumulation during the three-day interval. Different rate estimates (carcasses accumulating per day per quadrat) were calculated for each week based on additional dead birds found when quadrats were searched the second time. Weekly accumulation rate estimates were not biased by the mortality that occurred during previous weeks because prior losses were detected during initial searches each week.

Squaw Creek waterfowl losses were lowest prior to the opening of the regular waterfowl season (31 October) and declined after southern migration lowered area populations (Figure 1). Peak losses, indicated by weekly quadrat averages, were as high as six birds per acre. Estimates of the total weekly mortality on the study area indicated more than 600 ($\overline{X} \pm 95\%$ CI; 627 ± 194) carcasses on the 254 sample quadrats during mid-December 1981. Accumulation rates indicated the loss of a bird per 2.6 acres per day during peak periods of mortality. High accumulation rates preceded or accompanied periods when quadrat averages were highest, but declined before quadrat averages declined. This indicated that scavengers could not "keep up" with losses during peak periods of mortality. Projecting quadrat averages to the entire water/vegetation edge at Squaw Creek, nearly 900 birds

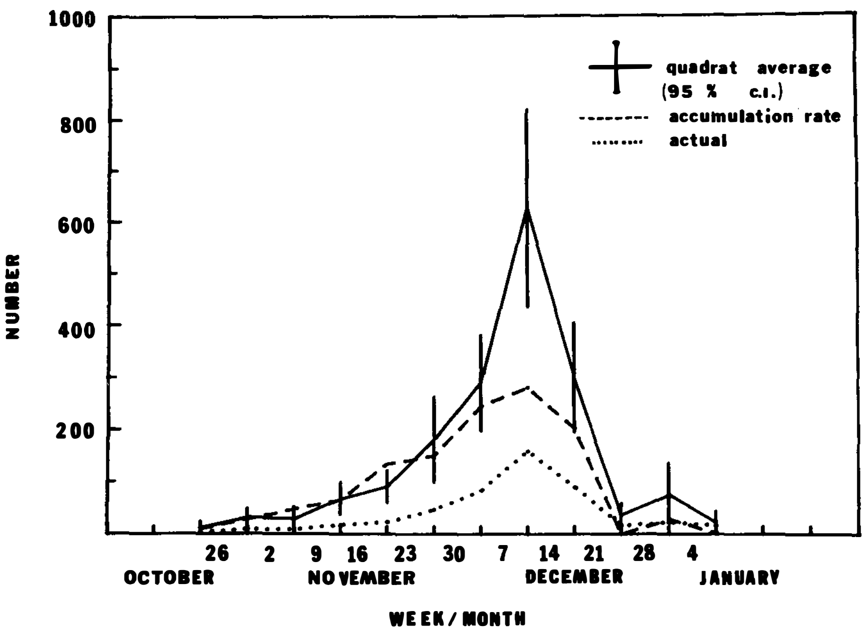

Figure 1. Numbers of carcasses found per week during 1981 quadrat searches at Squaw Creek and weekly estimates of waterfowl mortality based upon quadrat averages and accumulation rates.

could have accumulated following periods of greatest mortality. Rates of loss estimated from accumulation indicated the loss of about 2,000 birds on the study area during the October to January 1981 period.

Swan Lake waterfowl losses increased during the week following the waterfowl season opening (31 October 1981). Mortality indicated by shoreline quadrat averages increased until mid-December, then declined dramatically when population levels dropped and snow cover eliminated evidence of mortality (Figure 2). Estimates from shoreline quadrat averages indicated the occurrence of more than 400 (434 ± 154) carcasses on the 345 sample quadrats in mid-December. Losses as high as a bird per 12 acres (4.9 ha) of shoreline per day were indicated by accumulation rates. Accumulation rates projected to the entire shoreline acreage at Swan Lake indicated the loss of nearly 2,350 birds during the 12-week study. Because only 28 carcasses were collected on upland quadrats, estimates of total losses in these areas were questionable. Losses occurred in upland crop fields, but the relative magnitude was much lower than near water areas.

Spring quadrat sampling at Swan Lake and Squaw Creek was characterized by flooding and dispersed waterfowl populations and few losses were documented. Six birds were found on the two areas after 124.5 hours of quadrat search (Table 1). Birds were widely distributed and evidence of mortality was rapidly eliminated by scavengers and high water. Sampling intensity and frequency was not great enough to estimate the extent of spring waterfowl mortality.

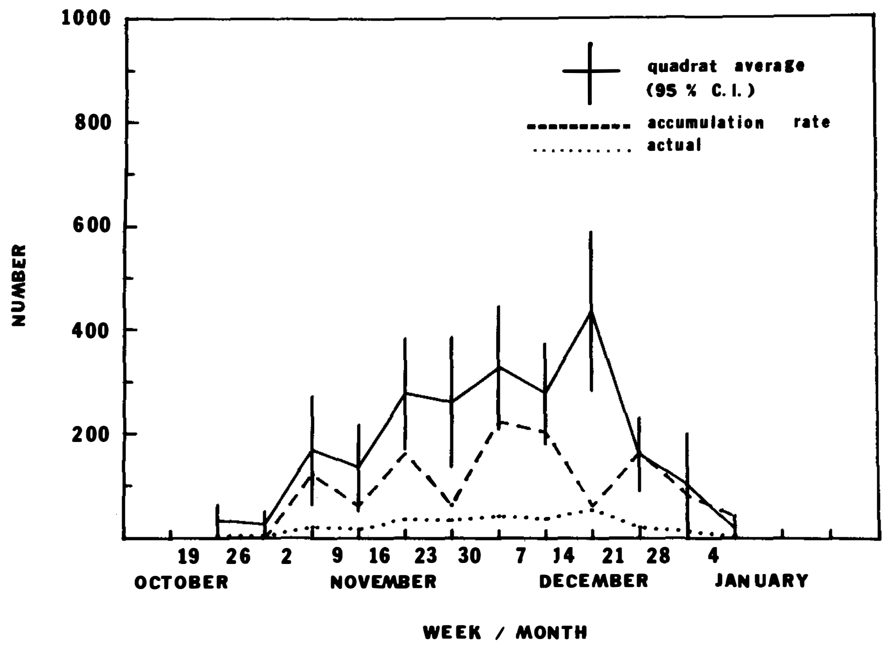

Figure 2. Numbers of carcasses per week during 1981 quadrat searches at Swan Lake and weekly estimates of waterfowl mortality based upon quadrat averages and accumulation rates.

Transect Sampling

The transect sampling technique utilized at Fountain Grove was similar in effectiveness to quadrat methods. A total of 123 birds was found in 184 hours of transect searching (0.67 birds per hour). A higher proportion of intact carcasses (42.3 percent) was found during transect sampling. Although efficiency rates were similar to quadrat sampling, assumptions required for total mortality estimates limited use of much of the data. Dog-retrieved birds, birds that were alive when located, and birds found in close proximity to, or as a result of finding other carcasses, were eliminated from total mortality estimates. Ninety-seven carcasses were used for statistical estimates of waterfowl mortality. Rates of loss as high as a bird per seven acres (2.8 ha) were estimated for two-week to three-week periods in late November and early December. For example, this indicated 81 ± 51 carcasses present in the 575 acre (233 ha) study area during the period 9 to 18 November 1981. Transect sampling allowed estimates of waterfowl loss on the study area; however, increased sampling intensity and adherence to precise field sampling methods would improve mortality estimates.

Variables Affecting Documentation of Mortality

Several factors affected rates of mortality or estimations of total losses. Weather, waterfowl population levels, scavenging, and vegetation effects on search efficiency were variables that affected the rate of mortality or detection of actual losses.

Population levels and weather affected numbers of birds lost. Numbers of carcasses found increased as populations levels increased, and losses were higher when weather conditions (cold, snow, etc.) were more severe. Water level fluctuation, snow cover, ice action, and wind were weather variables that obscured evidence of losses. Floods and snow cover eliminated evidence, ice affected logistics of search, and wind redistributed carcasses in areas of open water.

Search efficiency was affected by vegetation density, habitat type, and waterfowl species. Of 79 carcasses "planted" prior to search, 73 percent were located when quadrats were searched. Among species, search efficiency was highest for larger, more visible species such as snow geese and lowest for female dabbling ducks. A smaller proportion of "planted" birds was found in dense habitats such as upland crop fields than in areas of sparse cover along shorelines.

Scavenging was the most important variable precluding documentation of waterfowl losses. At Squaw Creek, 90 intact carcasses were located and checked periodically to determine carcass disappearance rate. The percentage of carcasses that disappeared during days one to four were 9.4, 12.2, 36.7 and 62.2 percent, respectively. At Swan Lake, 62 intact carcasses were observed daily until birds were depredated or disappeared. Scavenging rates, expressed as the percentage of carcasses depredated per day were 43.5, 67.7, 79.0 and 82.3 percent on day one to four, respectively. These observations indicated that about one-half of the carcasses were scavenged within one day (Swan Lake) and disappeared within four days (Squaw Creek). The primary avian scavengers were bald eagles *(Haliaeetus leucocephalus)*. Eagles increased in number from mid-November until peak populations of 140 to 180 at Swan Lake and 170 to 180 at Squaw Creek occurred in mid-to-late December. This corresponded to periods of peak waterfowl mortality. Coyotes *(Canis latrans)* were the primary mammalian scavengers.

Necropsy Analysis

Post-mortem examinations of 675 duck and goose carcasses showed the relative importance of mortality factors among species and study areas. Undetected, however, were losses due to an event such as predation. Cause of death was determined for 82.2 percent of the carcasses necropsied. Included for relative comparison were the proportion of carcasses determined to be gunshot cripples. Unretrieved ducks and geese, estimated to be about 20 percent of the total waterfowl downed by hunters, should be encountered commonly in areas when waterfowl hunting occurs.

All areas and species combined, crippling accounted for 47.1 percent of waterfowl mortality, followed by lead poisoning (34.2 percent) avian cholera (10.9 percent), aspergillosis (7.0 percent) and crop impaction (1.4 percent) (Table 3). The importance and temporal occurrence of different mortality factors varied among species and areas. Seventy percent of Canada geese necropsied from Swan Lake and Fountain Grove were the result of crippling loss during November and

Table 3. Mortality factors diagnosed in Canada geese, snow geese and mallards collected at Swan Lake NWR, Squaw Creek NWR and Fountain Grove WMA during 1980 and 1981.

		Diagnosed (82.2%)											Not diagnosed (17.8%)
		Gunshot		Lead poisoned		Cholera		Aspergillosis		Impaction			
Area/Species	Year	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)	Total No.	Total No.
Swan Lake NWR													
Canada geese	1980	51	(68.9)	5	(6.8)	6	(8.1)	8	(10.8)	4	(5.4)	74	23
	1981	24	(82.8)	2	(6.9)	0		2	(6.9)	1	(3.4)	29	2
Snow geese	1980	4	(57.1)	3	(42.9)	0		0		0		7	3
	1981	0		0		0		0		0		0	0
Mallards	1980	0		1	(100)	0		0		0		1	0
	1981	0		0		0		0		0		0	0
Fountain Grove WMA													
Canada geese	1980	37	(49.3)	11	(14.7)	25	(33.3)	0		2	(2.7)	75	14
	1981	26	(92.9)	1	(3.6)	0		1	(3.6)	0		28	7
Snow geese	1980	0		0		0		0		0		0	0
	1981	0		0		0		0		0		0	0
Mallards	1980	5	(8.1)	57	(91.9)	0		0		0		62	5
	1981	2	(66.7)	1	(33.3)	0		0		0		3	1
Squaw Creek NWR													
Canada geese	1980	2	(66.7)	0		1	(33.3)	0		0		3	0
	1981	11	(28.9)	0		1	(2.6)	26	(68.4)	0		38	3
Snow geese	1980	8	(40.0)	9	(45.0)	1	(5.0)	2	(10.0)	0		20	13
	1981	75	(43.6)	70	(40.7)	26	(15.1)	0		1	(0.6)	172	38
Mallards	1980	3	(21.4)	10	(71.4)	1	(14.3)	0		0		14	7
	1981	7	(24.1)	22	(75.9)	0		0		0		29	4
Totals	1980	110	(43.0)	96	(37.5)	34	(13.3)	10	(3.9)	6	(2.3)	256	65
	1981	145	(48.5)	96	(32.1)	27	(9.0)	29	(9.7)	2	(0.7)	299	55
Grand total		255	(45.9)	192	(34.6)	61	(11.0)	39	(7.0)	8	(1.4)	555	120

December. Crop impaction and aspergillosis occurred before mid-November and the incidence of lead poisoning and cholera was most frequent after mid-December. Similar in proportion of snow goose losses at Squaw Creek were crippling (43.2 percent) and lead poisoning (41.1 percent). Crippling losses corresponded to the hunting season, (November and December) while lead poisoning was a frequent cause of snow goose losses after mid-December. Avian cholera losses predominated snow goose mortality for short periods of time in early to mid-December. Lead poisoning was the most common mortality factor among necropsied mallards (83.5 percent) and occurred in both years at Squaw Creek and in 1980 at Fountain Grove. Most (85 percent) lead poisoned mallards were detected during December and January.

Required use of non-toxic shot appeared to reduce losses to lead poisoning. At Swan Lake, where steel shot was required throughout the study, lead poisoning was relatively infrequent, although it caused a high proportion of losses in small samples of mallards and snow geese. At Fountain Grove, a large number of mallards and a higher proportion of Canada geese than at Swan Lake were lost to lead poisoning when lead shot was allowed in 1980. The magnitude of lead poisoning losses declined dramatically in 1981 when steel shot was required. Squaw Creek lead poisoning losses were high in proportion and magnitude among mallards and snow geese during both years. No steel restrictions were in effect on areas surrounding Squaw Creek during 1980 or 1981. Predominance of lead poisoning at Squaw Creek was supported by examination of livers and/or gizzards collected from partially eaten carcasses not suitable for necropsy. Ingested lead shot was present in 40.4 percent of 94 gizzards examined, and elevated lead levels (exceeding 6 to 20 ppm; Longcore et al. 1974) occurred in 46.5 percent of 46 livers analyzed.

Birds lost to various mortality factors were not evenly distributed among habitat types. A total of 222 necropsied birds collected at Squaw Creek were categorized as alive (59) versus dead (163) and whether they were located in open water or vegetation/shoreline edge, on land, or in flooded vegetation. More lead poisoned (43 percent) than crippled (25 percent) birds were found alive and all necropsied birds with avian cholera (26 carcasses) and aspergillosis (24 carcasses) were dead when found. The proportion of total carcasses found dead on land or in flooded vegetation was highest for lead poisoning (57 percent), followed by birds lost to aspergillosis (42 percent), gunshot crippling (40 percent), and avian cholera (31 percent). Lead poisoned birds were more difficult to detect because they were more often found in vegetation and were therefore less visible. Higher proportions of live birds incapacitated by crippling or lead poisoning reflect the bias against detection of day-to-day chronic waterfowl mortality versus acute loss to diseases such as avian cholera.

Discussion

Evaluation of Search Methods

Methodical search of waterfowl concentration areas reflected the temporal occurrence of nonhunting mortality of ducks and geese and provided an index to the magnitude of losses and relative importance of different mortality factors. Use of specific sampling methods by wetland managers should be dictated by the objective of the search. One-day, post-hunting season search is a time-efficient method for documenting significant numbers of losses. Requirements include a large number of people and ice conditions that permit effective area coverage. The small number of intact carcasses found during one-day sampling precludes identification of mortality factors responsible for waterfowl losses.

Levee and shoreline search provides a method for periodic sampling of nonhunting mortality. A high proportion of intact carcasses is found because sampling efficiency is maximized by frequent search along shoreline areas where evidence of mortality commonly occurs. This provides a method for early detection and monitoring of disease incidence. Losses standardized per mile of levee or shoreline searched indicate temporal changes in waterfowl mortality, but do not provide reliable estimates of nonhunting losses.

Quadrat and transect sampling results provide statistical estimates of periodic waterfowl losses. Increased sampling intensity (area and frequency) improves the precision of mortality estimates and increases the number of intact carcasses suitable for necropsy. Although less efficient, quadrat sampling provided mortality estimates that were higher than the actual number of losses documented through levee and shoreline or one-day searches.

Estimating Fall to Winter Nonhunting Mortality

Daily search of entire study areas to determine magnitude of nonhunting losses is impracticable, and only a portion of actual losses are found through periodic sampling. At Squaw Creek NWR and Swan Lake NWR, quadrat sampling results were used to estimate losses of 2,000 or more waterfowl in water/vegetation edge or shoreline areas from late October to early January. Several factors affected search efficiency or eliminated evidence of waterfowl mortality.

Scavenging activity appears to be the most important factor precluding documentation of total losses. Nearly one-half the intact carcasses observed to determine scavenging rates at Swan Lake were evident only as feathers or wings and bones after one day. Data from Squaw Creek indicated that evidence from more than one-half the intact carcasses disappeared entirely within four days. These data suggest that a four-day interval between sampling would result in a 50 percent underestimate of mortality. Managers attempting to collect samples for necropsy would have to search every second day, according to Swan Lake data, to find one-half the carcasses intact.

Vegetation density, carcass visibility, and mortality factors involved are major factors affecting search efficiency. One-fourth of the carcasses "planted" on Swan Lake quadrats were not located when the area was searched. About one-fourth of the lead poisoned and crippled birds at Squaw Creek were found alive and nearly one-half collected dead; intact carcasses were located in vegetation or on land. Avian cholera losses usually were snow geese found dead and located in open water areas. Managers are more likely to detect losses such as avian cholera, while documentation of lead poisoning losses or unretrieved cripples may prove more difficult.

Dramatic weather impacts further affect estimates of mortality. Flooding, ice, and snow cover are seasonal variables that may prevent detection of waterfowl losses. In addition to affecting logistics of search, these factors may entirely eliminate mortality evidence. Combination of weather factors, variable search efficiency, and scavenging probably account for significant underestimates of nonhunting mortality by field search methods.

Importance of Fall and Winter Nonhunting Mortality

Nonhunting mortality during the fall and winter appeared to be relatively more important in mallards and snow geese than in Canada geese. Necropsy results do not indicate the actual magnitude of losses; however, the relative importance of nonhunting factors compared to crippling loss was indicated. Crippling losses predominated Canada goose mortality in necropsy samples from Swan Lake and Fountain Grove. Also detected were losses to avian cholera, lead poisoning, aspergillosis and crop impaction. Although much lower in proportion to crippling during 1980 and 1981 studies, post-hunting season losses to avian cholera or lead poisoning could become significant in some years. Presently, lead poisoning appears to be controlled through the mandatory use of steel shot; however, incidence of avian cholera should continue to be monitored at Swan Lake.

Except for lead poisoning, nonhunting mortality factors do not appear to significantly affect mallards in Missouri. Eight of ten mallards necropsied in 1980 and 1981 were lead poisoned. Predominantly from Fountain Grove and Squaw Creek, mallard lead poisoning losses were more frequent late in the hunting season or after seasons closed. Steel shot use appeared to reduce lead poisoning losses at Fountain Grove.

Compared to crippling losses, necropsy results from Squaw Creek snow geese indicate that lead poisoning and avian cholera are important nonhunting mortality factors. Reduced mallard and Canada goose losses at Fountain Grove and Swan Lake indicate that lead poisoning could probably be reduced through use of nontoxic shot near Squaw Creek. Avian cholera should also continue to be monitored on Squaw Creek NWR.

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Simulating Results of Management Actions on Mallard Production

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Introduction

Management of the continental waterfowl population requires that actions designed to influence the size and distribution of the population are taken by state, federal, and private agencies. Such management actions usually are designed to change either the survival or recruitment rates of the population. This paper describes a model to answer management questions about waterfowl breeding grounds of the northcentral United States, primarily the Prairie Pothole Region of Minnesota, North and South Dakota, and Montana (Mann 1974). The procedures that we developed are for the mallard, *Anas platyrhynchos,* a prized game species for which there are more biological data than for any other duck species.

Decisions required of waterfowl managers pose some difficult problems. For some questions the data are inadequate. For other questions there are a great deal of biological data available, but the ecological relations are so complex that immediate decisions must be made before the data are thoroughly examined by the manager or administrator. Often, studies or trials are proposed to evaluate specific management options, but, unfortunately, the results of hastily conceived studies are often too little, too late.

Recently, modeling has been suggested as an aid to making natural resource decisions (Lackey 1979), and models have been applied to a wide variety of natural resource and wildlife management problems. Walters et al. (1974) developed a simulation model of mallard populations. Their model predicted long-term population trends and changes in distribution of the population. One of the main purposes of their model was to identify areas of needed research. Ringelman and Longcore (1980) developed a similar model for the black duck, *Anas rubripes.* Models have also been applied to specific management problems such as harvest (Anderson 1975, Brown et al. 1976, Hochbaum and Caswell 1978), recruitment (Cowardin and Johnson 1979), and theoretical population ecology (Bailey 1981).

Our system (Figure 1) differs from previously published models in four important ways. It is far more detailed in its treatment of the components of the recruitment process. It is based on more recently published and unpublished data on mallard breeding biology than was available for previous modeling attempts. It is integrated with the current data bases to form a system that will allow the manager to address regional or site-specific questions. Finally, the data bases and the models in the system are designed to be updated as new data become available.

The system proposed here has three purposes. First, it is designed to synthesize a large amount of information on the basic biology of mallard production by incorporating that information into predictive models that simulate the function of a real population. Second, it is intended to make information available by entering

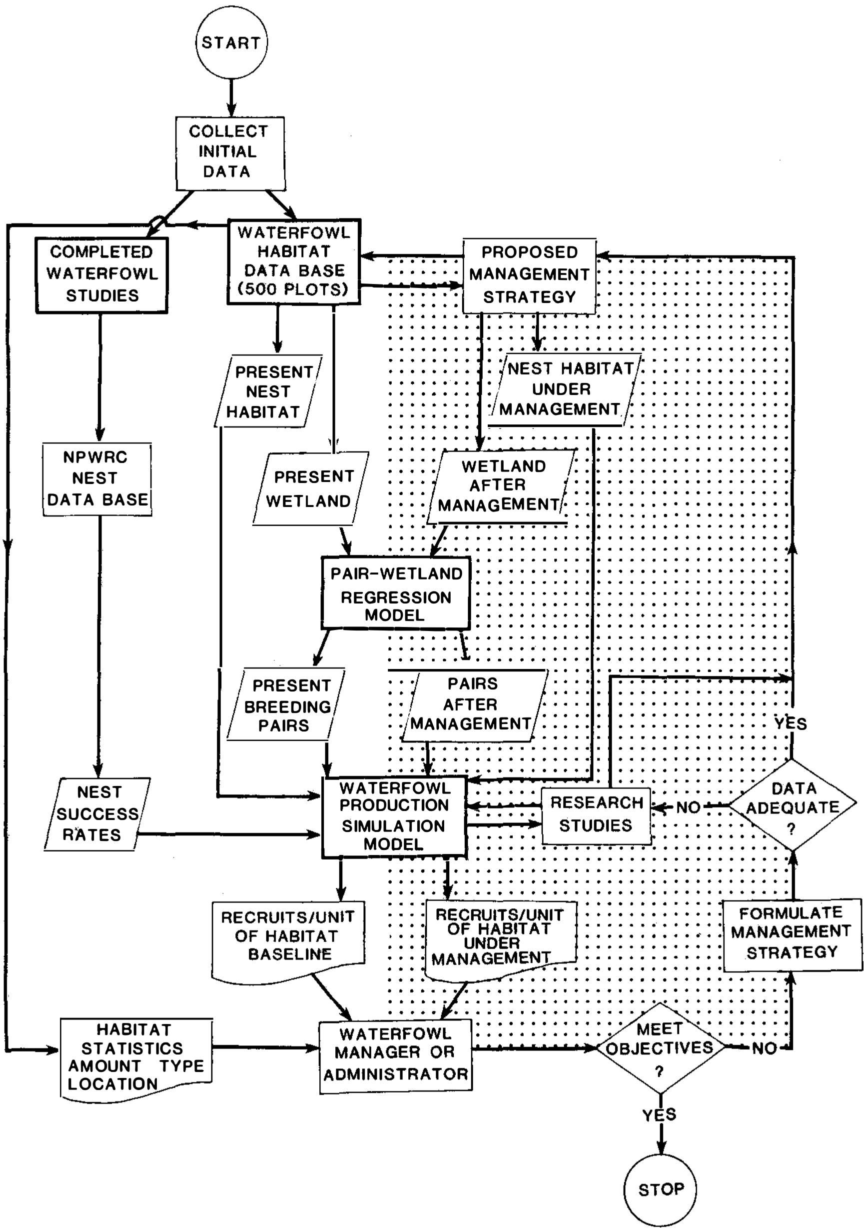

Figure 1. Flowchart illustrating a system for evaluating mallard management options. Shaded area denotes simulation under proposed management.

habitat data from sample plots representative of the Prairie Pothole Region into a computer file where rapid interaction with the predictive models is possible. Third, the system is intended to allow the waterfowl manager to make predictions as to the probable results of management options. These predictions may be used to select those options that hold most promise for meeting objectives.

Methods

There are four main components of the system (Figure 1): (1) nest data base, (2) waterfowl habitat data base, (3) pair-wetland regression model, and (4) stochastic mallard production model. These are coupled in a system that employs both computer programs and manual procedures. For current conditions, average nest survival rates and available nesting and pair habitat data are used to predict current populations and recruitment. Input data may be modified to simulate conditions under proposed management strategies. The user may also employ only parts of the system for specific applications.

The stochastic simulation model that performs a primary function in the system was originally developed by a group of biologists and statisticians at the Northern Prairie Wildlife Research Center to focus their research on the common goal of understanding mallard breeding biology (Johnson and Frank, Midwest Fish and Wildlife Conference Unpublished Report 1980). Later we modified this model to incorporate findings from recent studies, adapted it for predicting results of management actions, and coupled it with other models and data bases.

Nest Data Base

Numerous studies that involved finding waterfowl nests and determining their fate have been conducted over the past 20 years. The purposes of these studies varied greatly and resulted in different definitions, classifications, and coding systems. Results of some studies have not been published. We developed standardized classifications and codes and translated the various data to the standard format. The records were then placed in a computer file where they are readily and rapidly accessible. This data base is an integral part of our system; it also has many other potential uses. We are continuing to add data from past and ongoing studies. At present the file contains information on about 15,000 nests.

Habitat Data Base

The system is designed to apply to units of habitat either in their present condition or as modified under a proposed management strategy. We used 4-square-mile (10.4 km^2) plots as sample units. Any plot is large enough to encompass the home range of a breeding mallard (Dwyer et al. 1979, Cowardin, unpubl. data) and is also easily delineated on aerial photographs. We used a simple classification of nesting habitat composed of 10 classes: grassland, hayland, planted cover, cropland, scrubland, woodland, wetland, right-of-way, other habitats, and barren. The number and type of wetland basins were used to predict the number of pairs attracted to a plot. The basins were classified as temporary, seasonal, semipermanent, and permanent. We translated data from three existing wetland classification systems (Shaw and Fredine 1956, Stewart and Kantrud 1971, Cowardin et al. 1979) to this simplified classification.

We selected a stratified random sample of 500 plots designed to represent habitat conditions throughout the Prairie Pothole Region. Each plot was assigned to one of three strata based on the amount of land owned or under easement by the U.S. Fish and Wildlife Service. Samples were then selected from the strata. The service uses funds derived from sale of migratory bird hunting stamps to purchase waterfowl production areas (WPAs) where wetlands are protected and upland habitats may be managed. In addition, the same source of funds is used to purchase easements on private lands where the owner agrees not to drain, burn, fill, or level wetlands. Because of the interest in acquisition or management of these areas, we weighted the sample to favor the areas with ownerships or easements. Strata sizes and sampling rates were 3,186, 9.4 percent; 8,775, 1.1 percent; and 18,234, 0.6 percent for high, medium, and low ownership strata.

The boundaries of each plot were delineated on 1:24,000 U.S. Geological Survey maps. Habitats within the plots were interpreted and delineated on 1:63,560 color infrared photographs and transfered to map overlays by Bausch and Lomb zoom transfer scope.[1] In addition, legal boundaries of all easements and ownerships were transcribed onto a second set of overlays. All map data were digitized by means of WAMS (Pywell and Niedzwiadek 1980) and MASS (unpublished report, Autometrics Inc., Fort Collins, CO.) software. The data base constructed in this manner is being completed and will be used to test management options for the Prairie Pothole Region of the United States. For the present paper we present results from eight plots from a quadrangle named for Pearl Lake, North Dakota.

Pair-Wetland Regression Model

The relation between the number of breeding waterfowl attracted to an area and the amount of wetland habitat present has been demonstrated from survey data where ponds and ducks were counted (Crissey 1969). The relation is neither straightforward nor linear. It is influenced by both the types of water areas and their size. We developed individual regressions for each class of pond and related observed mallard pairs to the size of the area (Figure 2). Data were taken from four studies, the first three conducted by Stewart and Kantrud in 1967, 1968, and 1969 throughout North Dakota. Procedural details were given by Stewart and Kantrud (1972, 1973, 1974). The fourth study included six study sites near Devils Lake, North Dakota (H.F. Duebbert, unpubl. data). These data sets contained information on about 6,280 wetland basins. Our best fitting equations were obtained for $\sqrt{\text{area}}$ which serves as a proxy for shoreline length. The predictive equations provided highly significant fits to the data used. Nonetheless, there was considerable variation that was unexplained by the equations. Accordingly, the predictive equations are only approximate. We do not expect them to accurately predict the number of birds on a particular pond during a given year, but believe they will be effective in predicting the number expected for a variety of ponds on average over several years.

[1]Reference to trade names does not imply government endorsement of commercial products.

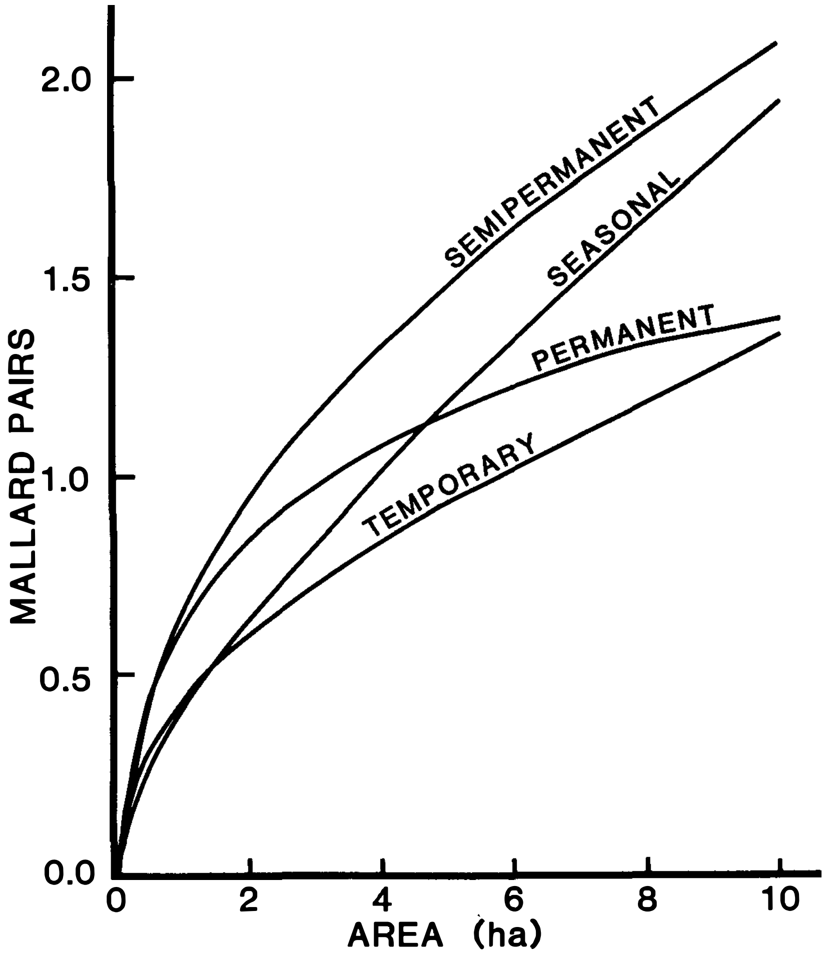

Figure 2. Relation between mallard pairs and size for four classes of ponds.

When using these equations, we assume that there are sufficient birds to occupy the available habitat. The production predicted by the model, therefore, should be viewed as the production potential of the habitat. We contend that annual waterfowl and pond counts indicate that the habitat fills from south to north, and we assume that in the United States' portion of the Prairie Pothole Region there are sufficient birds to occupy the habitat. This may not be true in northern Canada, especially in years when water conditions in the southern part of the breeding range are good.

Stochastic Mallard Production Model

Estimates of recruitment rate and total recruits produced on each sample plot are made from a stochastic simulation model. We had earlier developed a deterministic model (Cowardin and Johnson 1979), but the stochastic approach appeared to give a more realistic approximation of the behavior of a population of breeding birds and to offer greater flexibility for modeling management options. We agree with Lackey (1979:178) who stated, "Models which incorporate stochastic processes may provide better descriptions of population dynamics, especially when the processes are analogous to biological processes."

Input to the model consists of the area of each type of nesting habitat derived from map data for a plot, average nest survival rates for those habitats obtained from the nest data base, and typical water conditions throughout the season as supplied by the user for a specific application of the model.

We define recruitment rate as young hens recruited to the fall population per hen in the spring population. During execution of the model, each hen follows the process illustrated in Figure 3 on each day of the breeding season. Because the model is stochastic, results vary due to random effects; therefore, we use 500 hens

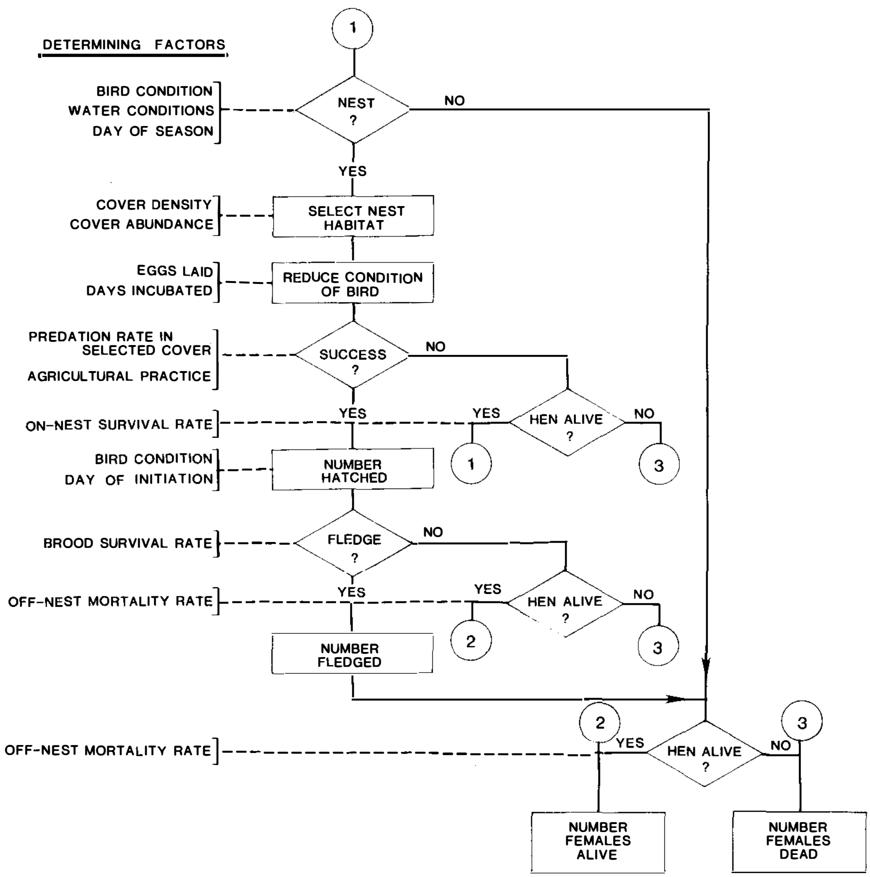

Figure 3. Simplified flowchart illustrating function of stochastic simulation model used to predict mallard recruitment rate.

in each application to reduce random variation. Recruitment rates obtained from the 500 birds are then applied to the breeding population predicted by the regression models to obtain a prediction of recruits produced.

Study Site

We illustrate use of the model with data derived from eight 4-square-mile (10.4 km^2) plots from a test site, Pearl Lake quadrangle, North Dakota (47° 00′00″ to 47° 7′30″N Lat., 99° 15′00″ to 99° 22′30″ W Long.). The procedures used in developing the data for the eight plots were equivalent to those being used on the 500 plots. The composition of the upland and wetland habitats on the test site is representative of that within the Missouri Coteau Biotic Province of North Dakota (Stewart 1975). The habitats within the test site compared closely (Table 1) to unpublished data from an earlier study (Cowardin et al. 1981). The pattern of land ownership on the test site is not representative of conditions in the Missouri Coteau or the Prairie Pothole Region because we intentionally selected a site with high density of U.S. Fish and Wildlife Service waterfowl production areas and easements to demonstrate management application of the model. The results that follow, therefore, can not be extrapolated to the region but are specific to Pearl Lake.

Management Options

In actual applications of the system, the user must carefully consider and state the questions to be asked of the model. Furthermore, to evaluate the quality of the data to be used, an understanding of the details of the model is required. Best results will be obtained through a cooperative effort by modelers and users. For some questions data will be insufficient and specific studies must be conducted before running a simulation (Figure 1).

We selected four management strategies to illustrate use of the system. These

Table 1. Composition of habitat on the Pearl Lake, North Dakota, test site compared to regional habitat in the Missouri Coteau.

	Percent composition				
	Pearl Lake test site				
Class	Easement	WPA	Private	Total	Coteau[a]
Grassland	36.7	56.5	33.0	37.6	37.9
Hayland	6.5	0.0	2.5	2.9	5.1
Planted cover	0.0	16.4	0.0	2.7	[b]
Cropland	41.9	7.6	46.9	39.4	38.3
Other[c]	1.5	0.6	1.4	1.3	2.4
Right-of-way	0.0	0.0	1.3	0.9	1.3
Wetland	13.4	18.9	14.9	15.2	14.8
All habitats	18.9	16.6	64.5	100.0	100.0

[a]Based on a sample of 66, 1.24-square-mile (3.22-km^2) plots.
[b]Planted cover included in grassland in the regional sample.
[c]Includes farmsteads, shelterbelts, rockpiles, and field borders.

strategies are related to actual practices but are not necessarily the best options available.

Case I, Purchase of wetland easements. Purchase of easements prevents wetland loss but has no immediate effect on waterfowl production. As drainage occurs on unprotected lands, the easements have the effect of slowing the rate of wetland loss and corresponding reduction in pairs attracted to the area. For our example, we assumed an annual drainage rate of 3.5 percent of the wetland basins per year and compared production in the tenth year after purchase on the Pearl Lake test site with easements to the same site without easements. In the simulation, easements were taken on plots with the greatest number of wetland basins not protected by present easements. New easements contained 578 acres (237 ha) of temporary, seasonal, and semipermanent wetland representing 42 percent of the unprotected wetland on the study site.

Case II, Purchase of waterfowl production areas. In our simulation we selected WPAs totaling 1,600 acres (648 ha) from two plots with a good base of wetlands protected by easements. We also simulated conversion of existing cropland within the selected WPAs to dense nesting cover (Duebbert et al. 1981).

Case III, Intensive management on existing WPAs. Mammalian predation is an important factor limiting waterfowl production (Duebbert and Kantrud 1974). Electric fencing is a potential new management technique for reducing this problem (Lokemoen et al. 1982). In our simulation, we selected five areas totaling 800 acres (324 ha) on existing WPAs with dense nesting cover. We simulated fencing these areas by increasing nest success in dense nesting cover from 20 percent to 55 percent, a figure slightly more conservative than that presented by Lokemoen et al. (1982).

Case IV, Land retirement. Upland nesting ducks benefit greatly from agricultural programs that add cover on private lands. Under the U.S. Department of Agriculture's soil bank program, which reached its peak in the early 1960s, up to 10 percent of the cropland in North Dakota was taken out of production and converted to grass-legume cover. We simulated such a program by changing 10 percent of the area mapped as cropland on the test site to planted grasses and legumes.

Results

As a check on the validity of the simulations, we compared results obtained from the control for Cases II-III (Table 2–4) to real data obtained in field studies in North Dakota. The model produces a number of statistics that aid in these validations. Results of the tests of management options can not be validated without major studies where the management techniques are applied over a large geographic area.

Current conditions. For comparison with previous studies we expressed breeding density, tabulated pairs/32 square miles (82.9 km^2) (Tables 2–4). Simulated pair densities were 11.1, 7.2, and 5.4 pairs/square mile (4.5, 2.9, and 2.2 pairs/km^2) in wet, average, and dry years. Stewart and Kantrud (1974) observed mallard densities from 9.45 to 6.4, mean = 6.9 pairs/square mile (3.8 to 2.6, $\bar{x}$ = 2.8 pairs/km^2) during 1967–69. Simulated recruitment rates were 0.494, 0.443, and 0.258 in wet, average, and dry years. Cowardin and Johnson (1979) summarized data from a number of North Dakota studies and presented a recruitment rate of 0.50. In a

Table 2. Simulated mallard production under six management options applied to a 32-square-mile (83-km^2) test area at Pearl Lake, North Dakota, in a wet year.

Case	Treatment	Pairs	Recruitment rate	Fledged young	Summer hen survival	Population change
Control for Cases II–IV	No treatment	370	0.494	366	0.749	0.99
Control for Case I	30% drainage of temporary, seasonal, and semipermanent wetlands	310	0.498	309	0.742	0.99
I	30% drainage except on 586 acres (237 ha) under easement	342	0.502	343	0.754	1.00
II	1,600 acres (648 ha) of new WPAs purchased and cropland on new WPAs planted to cover	370	0.540	400	0.762	1.04
III	Fence 800 acres (324 ha) of existing WPAs with predator repellent fencing	370	0.588	436	0.764	1.08
IV	Retire 10% of cropland and plant dense nesting cover	370	0.544	403	0.758	1.04

Table 3. Simulated mallard production under six management options applied to a 32-square-mile (83-km^2) test area at Pearl Lake, North Dakota, in an average year.

Case	Treatment	Pairs	Recruitment rate	Fledged young	Summer hen survival	Population change
Control for Cases II–IV	No treatment	240	0.443	213	0.754	0.96
Control for Case I	30% drainage of temporary, seasonal, and semipermanent wetlands	210	0.406	164	0.761	0.95
I	30% drainage except on 586 acres (237 ha) under easement	221	0.393	174	0.757	0.92
II	1,600 acres (648 ha) of new WPAs purchased and cropland on new WPAs planted to cover	240	0.471	227	0.762	0.99
III	Fence 800 acres (324 ha) of existing WPAs with predator repellent fencing	240	0.534	256	0.764	1.04
IV	Retire 10% of cropland and plant dense nesting cover	240	0.516	248	0.770	1.03

Table 4. Simulated mallard production under six management options applied to a 32-square-mile (83-km²) test area at Pearl Lake, North Dakota, in a dry year.

Case	Treatment	Pairs	Recruitment rate	Fledged young	Summer hen survival	Population change
Control for Cases II–IV	No treatment	182	0.258	94	0.790	0.844
Control for Case I	30% drainage of temporary, seasonal, and semipermanent wetlands	156	0.268	84	0.787	0.850
I	30% drainage except on 586 acres (237 ha) under easement	166	0.267	89	0.783	0.845
II	1,600 acres (648 ha) of new WPAs purchased and cropland on new WPAs planted to cover	182	0.294	107	0.796	0.877
III	Fence 800 acres (324 ha) of existing WPAs with predator repellent fencing	182	0.328	119	0.763	0.901
IV	Retire 10% of cropland and plant dense nesting cover	182	0.355	126	0.806	0.932

recently conducted study with radio-marked birds, Cowardin (unpubl. data) estimated a recruitment rate of 0.27. The summer survival rates predicted by the model are in close agreement with those derived by Johnson and Sargeant (1977:22) who presented a female summer survival rate of 0.715.

We had actual data for a large waterfowl production area near Woodworth, N.D., gathered from 1977 to 1979. In a previous test of the model, we used habitat data from this WPA and ran the model to obtain predictions of successful nests, 13.2; nest initiations, 68.9; nests/hen, 1.78; and hatch rate, 0.224. The actual data derived from nesting studies gave estimates of 13.8, 74.3, 1.55, and 0.186 for the same variables.

The model demonstrates the great importance of weather to mallard production by estimating 74 percent fewer recruits in a dry year compared to a wet one (Tables 2 and 4). Not only were fewer birds attracted to the area in dry years, but also a decline in nesting effort was evident in model results. The results suggest that if the mallards using the test area were treated as a closed population, the population would be stable (population change = 1.0) only in wet years. Actual populations on a local area may increase or decline because of new birds pioneering to the area.

Management Case I. The purchase of easements did help to slow the rate of loss of pairs attracted to the area and thus 11 percent more recruits are produced with easements; but since the recruitment rate is virtually unchanged there is no improvement in rate of population change. Note that for Case I, comparison of change is with the drainage occurring on all unprotected wetlands after a period of 10 years. Had we compared production to present conditions as in Cases II–IV we would show losses of 23, 39, and 8 recruits produced in wet, average, and dry years even with the new easements.

Management Case II. Purchase of new WPAs resulted in gains of 34, 14, and 13 recruits over current production in wet, average, and dry years (Table 5). There was no change in the wetland density. The gain in recruits came from increased recruitment rate resulting from replacing cropland with dense nesting cover. The model predicted that this management option would lead to an increasing population in wet years, an essentially stable population in average years, but as with all cases tested, the population would still be declining in dry years.

Management Case III. Fencing on existing WPAs with predator-resistant fencing resulted in the highest gain in recruitment rates and total recruits produced (Table 5). Furthermore, under this treatment the predicted population increased in both wet and average years. The model is particularly sensitive to changes in nest survival rate in preferred covers because birds within the entire plot can move to small areas of safe cover. This explains why treatment of only 800 acres (324 ha) in the 32-square-mile (82.9 km^2) test site had a major impact on production.

Management Case IV. Retirement of cropland yielded the second highest production of the options tested and resulted in predicted populations increasing in both wet and average years. Although the hatch rate in unfenced cover is not nearly as high as in protected areas, retiring 10 percent of all cropland resulted in a large area of planted cover. In an actual test over a wide area where federal land ownership is minimal, we would expect such a management strategy to be particularly effective if wetland habitat was also present.

The simulations also suggest a less obvious result. Examination of Tables 2–4

Table 5. Simulated gains in production of fledged mallards from a 32-square-mile (83-km^2) test area at Pearl Lake, North Dakota.

		Gain in recruits					
		Wet year		Average year		Dry year	
Case	Treatment	No.	Percent	No.	Percent	No.	Percent
I	586 acres (237 ha) of new easements[a]	34	11.0	10	6.1	5	6.0
II	1,600 acres (648 ha) of new fee purchase and plant cover on cropland	34	9.3	14	6.5	13	13.8
III	Fence 800 acres (324 ha) of existing WPA with predator repellent fence	70	19.1	43	20.2	25	26.6
IV	Retire 10% of cropland and plant cover	37	10.1	35	16.4	32	34.0

[a]Compared with area without easements in 10th year after easements are purchased. Three and one-half percent annual drainage rate assumed for temporary, seasonal, and semipermanent ponds.

reveals a higher summer survival of hens in drier years. This is because nesting effort is reduced in dry years and hens are therefore less apt to be on the nest where they are at high risk.

Future Applications

Flexibility of this system makes it adaptable to a variety of potential uses. It may be applied to a specific site if the user supplies habitat data. We have already used the model to evaluate the potential of alternative mitigation plans (unpublished report: "Change in mallard production on a 4-mi^2 test site at Rush Lake, North Dakota, based on results of a simulation model." December 1982, Northern Prairie Wildlife Research Center). The model could readily be used to give a quantitative estimate of the production potential of alternative areas for puchase as WPAs. The model also shows promise as a tool for improving annual production estimates for public lands and comparing them with estimates for private lands.

Consideration of the economics of mallard production is beyond the scope of this paper, but such an analysis is possible in conjunction with the model. If the user develops estimated costs for a management alternative to be tested, the estimated recruits produced can be expressed as recruits per dollar.

The quality of the predictions derived from the model can be no better than the quality of the data used. We plan to use the model to aid in demonstrating areas where data are meager for answering specific management questions. We have shown that the model is particularly sensitive to nest survival rates. Despite the fact that our data base contains a large number of nest records, we found that some geographic areas and important habitat types were poorly represented. A cooperative effort with the States in the Central Flyway is planned to gather data for these areas.

We also believe that the portion of the model dealing with brood survival needs strengthening through specific studies. Such studies are difficult and, therefore, have not received sufficient research attention in the past.

The answers to a number of management questions will require looking at the fate of a population over a period of years. At present, we merely furnish estimates of change from one year to the next for a population assumed to be closed. More realistic predictions will require research on homing, pioneering, and the density dependent factors that must operate on an increasing population.

In conclusion, we believe that the system presented here can be used to guide management decisions on the breeding grounds within the limits of our current knowledge of mallard biology. In addition, it forms a focal point for synthesis of current knowledge and points out areas where new information is needed to aid in making sound management decisions in the future.

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New Dimensions in Ducks Unlimited's Waterfowl Programs

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It has been seven years since I last spoke before this distinguished group, and so much has changed so quickly it is hard to keep up with it all.

Like it or not, (and I don't always) life is nothing but a series of changes. We must accept that, first, because there is nothing we can do about it anyway and, second, because change usually means growth.

There are only a few things I can think of that haven't changed in the past seven years. One, for sure, is that seven years ago I was at this very conference to address the subject of the loss of wetlands in North America. That hasn't changed much. We are still losing some 450,000+ acres (182,250 ha) of wetland habitat annually in the U.S. alone.

Two other things that haven't changed are Ducks Unlimited's commitment to stemming wetland habitat loss through its projects in Canada and Mexico and the remarkable growth Ducks Unlimited has experienced. Seven years ago we closed out the year with $8.1 million. Last year's figure was $34.7 million.

But, Ducks Unlimited *is* changing or, perhaps more specifically, broadening its horizons, and that's precisely what I am here to talk about. For the first time in its 46-year-history, Ducks Unlimited will begin developing waterfowl habitat in the United States.

For anyone to understand the importance of that announcement, he must understand that, since its inception in 1937 and until 1972 when it began habitat work in Mexico, Ducks Unlimited has concentrated *all* of its habitat restoration work in Canada where some 75 percent of North America's waterfowl nest.

We have, we feel, done a credible job, having spent $146 million on 2,100 projects over 3-million acres (1.2 million ha). Of course, there is still much, much more to be done. While we like to think of ourselves as land stewards, what Ducks Unlimited really is, is an insurance policy for the kinds of years which waterfowl have suffered through for the past three years. We offer them water when nature doesn't and agribusiness won't.

Political boundaries, of course, mean nothing to wildlife. A duck doesn't know whether it is in North Dakota or Manitoba, or whether when times get tough it should blame Reagan or Trudeau.

One of the first problems we encountered when we began considering expanding our efforts—and let me add now that we don't expect our Canadian work to be affected whatsoever by our involvement in the U.S.—was exactly where the wetland areas were located in the United States that needed help. At first glance, that might seem obvious . . . Alaska, North Dakota, South Dakota, Montana and Minnesota. But, Ducks Unlimited has to be far more precise than that if we intend to convince our 455,000 members of the need for their money.

While researching the possibility of developing a U.S. habitat program, we learned one rather startling fact: There is a suitable wetland inventory complete on only half of the program area that was designed for inventory 10 years ago, and that program area includes only one-half of the U.S. Of course, the U.S. Fish and Wildlife Service can tell you where the potholes are, but—and this is in no way meant to depreciate the efforts of Fish and Wildlife because it has operated for all these many years with a shortage of funds—it cannot provide you information such as relative acreage of deep and shallow water, vegetation types, and perimeter and shoreline/area ratios, which are all necessary to properly manage wetland habitat. And that is why Ducks Unlimited has entered into an agreement with NASA to inventory, via a remarkable new satellite, Landsat 4, critical wetland habitat in the United States. With Landsat 4, we will be able to interpret data and inventory wetlands like never before.

From a technical standpoint, the satellite provides a computer generated image, based on the energy level reflected from various substrates on the ground. Rather than the four bands provided by Landsat 3, the newest satellite will provide 7 bands (slices of the electromagnetic spectrum) of information.

The principal applications of these 7 bands for management purposes are as follows:

Band 1 Open water mapping; soil/vegetation differentiation; deciduous/coniferous differentiation
Band 2 Green reflectance by healthy vegetation
Band 3 Plant species differentiation
Band 4 Biomass surveys; water body delineation
Band 5 Vegetation moisture measurement; snow/cloud differentiation
Band 6 Plant heat stress measurement; other thermal mapping
Band 7 Hydrothermal mapping

Landsat 4 provides 30 meter resolution—about one-quarter acre—which is far more accurate and far more valuable in terms of management than any surveys that the Fish and Wildlife Service can now afford.

The Landsat 4 satellite covers every square foot of the earth every 16 days. Consequently, we will be able to ascertain, for the first time, quantitative trends in our wetlands—trends that cover entire water cycles. We will be able to predict siltation rates and, hopefully, we will be able to establish remotely sensed criteria that will allow us to predict the productivity of wetlands. Important factors such as shoreline length and vegetation density can also be determined with Landsat 4.

We will be using Landsat 4 along with our Canadian biologists not only for inventory, but to monitor critical habitat changes occurring in the pothole region. With such improved monitoring we can, in some cases, better respond with appropriate remedies.

We thought long and hard before deciding to include the United States in our List of Projects. The overriding argument *for* our entering the U.S. is the fact that 85 percent of the waterfowl in the lower 48 states are produced in the pothole regions of the Dakotas, Montana and Minnesota. Furthermore, those areas account for 17 percent of all North American waterfowl production.

Now, then, what about the Fish and Wildlife Service and its efforts? We don't intend to supplant those efforts. We want to enhance and complement them.

More than 2-million acres (0.8-million ha) of prime waterfowl breeding habitat are controlled by the Fish and Wildlife Service, principally in the prairie area, as a result of the Federal Migratory Waterfowl Stamp Act, which is known simply as

The Duck Stamp. Fee title and easement acquisition to these lands have cost more than $112 million. As a result, there is little money now being spent to maximize the production potential that exists there. In fact, a substantial reduction has occurred annually in habitat development funds each year since 1980, which makes the job Ducks Unlimited is trying to do even more critical.

When we started considering the move into the U.S., one of our officers asked me why we didn't let the numerous conservation organizations in this country take care of wetland habitat here. He mentioned the Nature Conservancy, The Audubon Society, The Sierra Club, and the National Wildlife Federation. The fact is, that while the Nature Conservancy does, indeed, acquire land and, to a lesser extent manage some areas, it does not specifically address comprehensive wetlands management. The Audubon Society has a network of sanctuaries managed for wildlife and interpretive programs, but its holdings are too limited in size when you consider the overall needs of waterfowl habitat. The Sierra Club is more of a watchdog organization, raising red flags and going to court where it deems necessary. And, the National Wildlife Federation does a fine job of education. But, it puts little money into directly saving the habitat that is each year being lost in the U.S.

That pretty well leaves it up to us. That was much the message we sent to our past presidents and trustees who, earlier this year, approved our entering the habitat program by better than 9 out of 10.

A little bit ago, I mentioned that change is a part of life, but that the U.S. wetlands picture hasn't changed from the bleak portrait I painted here seven years ago. Actually, it's been bleak for a lot longer than that. We know, for example, that around 1620, William Bradford, governor of The Plymouth Colony, warned of the decline of waterfowl. By 1710, less than a century after Bradford's warning, Massachusetts prohibited the use of certain watercraft—what we now know as sneakboats—to take waterfowl. So, it is obvious that the concern for the waterfowl of North America has been around far longer than any of the agencies that today try to protect it. In fact, it took more than three centuries after Bradford's warning for any private group to get serious enough over the decline of waterfowl to funnel its resources into the effort. That's when Ducks Unlimited entered the picture.

One of the tenets upon which Ducks Unlimited was founded had to do with the futility of laws regulating waterfowl hunting without protecting habitat. More than 200 years of hunting regulations had done little to stem the decline of waterfowl. It was obvious that the key to waterfowl production lay in habitat.

Peter Matthiesson, in his book, *Wildlife in America,* wrote: "The variety and splendid waterfowl of North America have been decimated since early times, and, though we can attribute the original losses to such practices as market gunning and spring shooting, the fact is that bad land management, drought, and excessive drainage, in combination with the usual ravages of civilization, have since destroyed most of the waterfowl breeding and wintering habitat in the nation; in other words, the ducks, geese and swans would be far reduced in number today even if never besieged by shot and shell."

Of course, I assume that all of you here are as interested in the perpetuation of waterfowl as Ducks Unlimited is. But, even allowing that you don't care one iota for a duck or goose, you still have to appreciate the value of wetlands. Because, besides the 30 species of ducks and geese that utilize wetlands, Ducks Unlimited biologists have documented use of such areas by 40 mammal species, 19 species of fish, and more than 300 other species of wildlife.

Other studies have found that species which live in estuaries and tidal marshes inhabit one of the most extraordinarily fertile of all environments. Studies of Georgia salt marshes conducted by ecologist Eugene Odum show that they produce 10 tons of organic material per acre per year, a figure that Odum compares with the most fertile hayfields, from which only some 4 tons can be harvested annually. A study by the Georgia Water Quality Control Board of Mountain Creek, a tributary of the Alcovy River, showed that water heavily polluted with human sewage was designated clean after passing through 2.75 miles (4.42 km) of swamp forest. A study of the Tinicum Marsh, located a few miles from the Philadelphia Airport, measured pollutants in the broad tidal creek which transects the marsh both before it overflowed its banks into the marshes and again when the water returned to the creek after draining for 2–5 hours. Chemical and bacteriological samplings indicated that the marshes significantly improved water quality by increasing the oxygen content and by reducing nutrient load. Ducks Unlimited Canada is now involved with a research project at the Saskatoon Campus of the University of Saskatchewan to study the feasibility of using marshes in place of costly tertiary treatment.

At the root of the solution—and I mean that literally—are the bulrush and cattail. The two marsh plants, it has been shown, have insatiable appetites for raw sewage. In fact, their capacity for neutralizing the harmful effects of the polluting pair—nitrogen and phosphorous—borders on the miraculous. "Any other plants take only enough for themselves," says the project's supervisor, "But the bulrushes and cattails take much more than they require." The roots of the plants produce an antibiotic substance that attacks and kills human and animal fecal bacteria. The root system also absorbs dangerous chemicals present in domestic sewage, trapping the toxic elements in their tissues and, in some cases, breaking them down into harmless elements.

And as for flood control, a 10-acre wetland, for example, stores 1.5-million gallons (5.7-million l) of water when there is a 6-inch (15-cm) rise caused by rains. And, I haven't even touched upon the benefits to livestock that come from a constant water supply.

So it is obvious wetlands have value, notwithstanding the production of wildlife. Environmental economists estimate that it would cost society $50,000 to $80,000 to replace all of the functions that just one wetland acre performs.

To be more specific regarding Ducks Unlimited's U.S. Habitat Program, we have prioritized three areas. The first priority, as you might expect, is in the Prairie Potholes of North Dakota, South Dakota and Montana. Next, we intend to look at the Prairie Potholes in Western Minnesota and then the prime production wetlands of Alaska. And that will keep us pretty busy for at least the rest of the century.

You might ask why we are not planning to get involved throughout the country, saving somebody's favorite marsh in Alabama or a remnant pothole outside Cleveland. The fact is, we would like nothing better than to expand throughout the country, but, at this point, we don't have those kinds of resources. Which is not to say that our current goals are less than ambitious. This year, for example, we are expecting to raise $41.6-million, $7-million more than we raised in 1982, which was more than we had ever raised before. The majority of the construction money—something close to 80 percent—will go to Canada (where we expect to work on some 300 new projects) and to Mexico. We now have more than 3.2-million acres (1.3-million ha) of wetland habitat reserved in Canada.

For those of you not familiar with our operation, there is a Ducks Unlimited in the U.S., a Ducks Unlimited Canada, and a Ducks Unlimited de Mexico (DUMAC). All three are separate entities living under the same roof, as it were. In a way, it has been like a traditional family. We make the money in the U.S. and everybody else gets to spend it. But, like the traditional family, our relationships are changing. Ducks Unlimited Canada has begun its own fund-raising efforts. Last year alone, it raised $1.2-million from more than 19,000 members, an accomplishment which makes us proud.

In 1983, Ducks Unlimited Canada will develop 300 projects representing more than 40,000 acres (16,200 ha). In addition to new developments and carryovers, 45 existing projects representing 14,755 acres (5,976 ha) will be improved across Canada.

In 1973, Ducks Unlimited was the first private conservation organization to enter Mexico. By the end of this year, we will have spent nearly $4-million on habitat restoration projects important for wintering waterfowl.

Also, Ducks Unlimited de Mexico (DUMAC) is developing a project in Honduras to help the rare Muscovy duck. Our current and planned projects in Mexico cover some 259,350 acres (105,000 ha) and benefit not only waterfowl, such as the rare masked duck, but other avian species including flamingos, chachalaca, and a host of shorebirds.

Ducks Unlimited is truly an international effort, spanning oceans and continents. Besides the aforementioned countries, there is a Ducks Unlimited New Zealand, and plans are complete for fund-raising dinners in South Africa, the Federal Republic of West Germany and Finland. In 1982, we had our first-ever dinner in Saudi Arabia. There, one of the auction items was a barrel of oil. Trouble was, each bid brought the price lower. Little wonder we didn't make as much money on that dinner as I had expected.

There are, of course, many details to be worked out for our entry into the restoration and management of critical wetland nesting habitat in the United States. We know that the course we have set will not be without its hazards. We know we will be laying ourselves open to all sorts of criticism . . . from those who claim we are not doing enough in Canada to those who claim we might be usurping the privilege of governments to accept more of their responsibilities.

We will welcome any and all criticism—in fact, I expect the first significant criticism to come here and will be a little disappointed if it doesn't. Because, I have always believed that the only effort that cannot stand up to criticism is the poor effort. And, any of you who know anything about Ducks Unlimited, knows that we don't even acknowledge poor efforts in our midst.

Regarding criticism, I rather think Sir Winston Churchill hit the nail on the head when he said: "Nothing in life is so exhilarating as to be shot at without result." Which is probably why the ducks are grinning when they fly over my blind.

But, I have to attribute to the English statesman Benjamin Disraeli my personal motto for Ducks Unlimited: "The secret of success is constancy of purpose."

The entry of Ducks Unlimited into U.S. projects does not waiver from our constancy of purpose. Rather, it simply and quite logically follows our pattern of growth. Frankly, we are thrilled by the prospect of it all. I thank you for your time and I welcome your comments, questions and criticisms.

Waterfowl Management Plans: A United States Perspective and Implementation Plans

Robert A. Jantzen
Director, U.S. Fish and Wildlife Service
Washington, D.C.

Just a year ago, at the National Waterfowl Council meeting held in conjunction with the North American Wildlife and Natural Resources Conference at Portland, I announced that Assistant Secretary Arnett had approved a National Waterfowl Management Plan. The plan's purpose was outlined in its opening paragraphs:

- to set forth a national goal for waterfowl in the United States;
- to guide the Service and the States, and others who work with us, in cooperative efforts to manage waterfowl;
- to provide a basis for developing species and population management plans at the flyway level; and, finally,
- to contribute to the eventual development of an international waterfowl management plan.

I would like to share with you my perspective on each of these four elements, and review what is being done to implement the plan.

National Goal

The goal to "perpetuate and improve waterfowl populations for the benefit of people" is a positive statement that reflects both our responsibilities under the Migratory Bird Treaty Act and our duties as public servants. Our intention and desire, even obligation, is to make optimum numbers of this renewable resource available for utilization, including hunting, viewing, and the other activities that give people enjoyment. We are responsible to assure that utilization has no long-term adverse effect on the status of populations.

Management Guidelines

I am pleased that waterfowl management has evolved during the last decade into a highly cooperative Federal-State arrangement. The Federal government has specific responsibilities for waterfowl, stemming from four migratory bird treaties and the direction provided by Congress. The States also have responsibilities for waterfowl because of their basic role in wildlife management under our Federal System of government. Waterfowl management is one of the Service's most important activities, but the task is too large to be handled solely by one agency; State participation is essential if the goal we spoke of a moment ago is to be achieved. For this reason, State fish and wildlife agencies have a direct interest and concern in implementing a national waterfowl management plan. I'm pleased to say they have demonstrated that interest by contributing much of the plan's development. The resulting plan is exactly the kind of product we want to see under the Department of Interior's fish and wildlife policy regarding State-Federal relationships: respective roles and responsibilities are defined and areas where cooperation is necessary are identified.

Species and Population Management Plans

With a goal established for waterfowl and a partner relationship in place, agencies can work together for the public benefit. The waterfowl flyway councils have done yeoman service in the development of species and population management plans. These plans, tailored to fit the conditions and needs of a flyway, have been cooperatively developed by state, provincial, and federal specialists. They may differ somewhat in format, but the plans generally identify goals and the tasks that must be completed to achieve them. Responsibilities are fixed for specific actions, and the plans often include a mechanism for periodic review and updating. Collectively, these plans will provide a basis for flyway management plans. Our flyway representatives have been catalysts for this work, but much of the credit for the actual development of plans goes to biologists and managers from state and provincial agencies and the Service's Regional Offices and field stations. The broad guidance provided in the national plan is narrowed in these flyway plans to the point that specific tasks can rationally be assigned to field staff. Management plans for 14 species or populations of waterfowl have been completed under the aegis of flyway management planning. These plans address six populations of Canada geese, three populations of snow geese, two populations of white-fronted geese, the Pacific brant, the mid-continent population of trumpeter swans, and the black duck. Another 20 plans are in preparation, and 6 others are scheduled for development.

I am pleased at the progress that has been made in this cooperative effort. While I am satisfied that a great deal has been accomplished already, I am anxious to see even more rapid progress with certain species that I feel deserve special consideration. For example, I would like to see management planning begin now for the mallard and the canvasback and be accelerated for such species of special interest as the cackling Canada goose and the Mississippi Valley Population of Canada geese. I have asked the Service's migratory bird staff to begin working with their counterparts in the States to develop or complete plans for these species in 1983.

Some of the existing species plans do not set forth quantified objectives. The absence of specific numbers may lead to a misunderstanding among those responsible for implementing such plans, so I have asked my staff to help establish, whenever possible, numerical objectives for breeding populations, fall flights, harvests, winter populations, etc., as appropriate. Having a specific number to aim at makes better sense than striving for undefined targets. I realize that technology is lacking to establish numerical objectives for some of these parameters, but it is worthwhile to establish them where possible.

Decisions have not been made about implementation strategies or priorities, and none will be made without consultation with the States and our treaty partners. However, I want to share with you some of the questions relating to such decisions that I have asked my staff to consider and provide me with their recommendations. For example, what emphasis should be given to gathering more accurate data on the population status of waterfowl species? What priority should be given to determining the relative importance of factors limiting populations, e.g., disease, lead poisoning, starvation, predation, nutrition, pesticides, habitat deficiencies, hunting, etc.? Should more emphasis be focused on controlling predators or intensively managing habitat on Waterfowl Production Areas? What practical steps can be taken to minimize disease losses? What legislation or other action is needed to encourage effectively landowners to preserve wetlands and to discourage agricultural practices that destroy waterfowl habitat? It is significant that Secretary Watt is supportive of initiatives that encourage the private retention of wetlands.

International Management Plans

With a national management plan established and second level planning well underway in the U.S., I believe it is time to consider waterfowl management planning at the international level. In a preliminary way, I have discussed how we might best proceed in this endeavor with my counterparts in Canada and Mexico. Based on these discussions, it appears now that the appropriate course of action will be for the U.S. and Canada to begin bilateral discussions on this subject as soon as possible. We will keep Mexican officials informed of our progress and be ready to have them join us as soon as they feel it is appropriate for them. As it stands at the moment, we expect to begin talks with the Canadian Wildlife Service early in 1984 with the aim first of identifying problems of mutual concern and developing options for cooperative strategies and policies. We know that developing an international waterfowl management plan will not be an easy task. Nevertheless, it is one that must be undertaken. The most crucial problems facing waterfowl management in North America today transcend national boundaries and cannot be dealt with successfully with less than international consideration. We have no preconceived solutions for these problems, but we look forward to working with our friends to the north and south.

Implementing the NWMP

Preparing plans and selecting priorities are challenging tasks, but ahead lies the greater challenge of implementation. For example, we may all agree that the preservation of existing waterfowl habitat is desirable, but doing so is a staggering task. It seems obvious that public protection of key habitat areas through acquisition or easement should be a continuing part of the wetland protection effort. But public ownership or control by itself is not an adequate response to the problem of dwindling waterfowl habitat. It is clear that governments do not have and are not likely to get the funds necessary to preserve a satisfactory portion of the remaining waterfowl habitat base. We must look elsewhere for help and the most likely source is the private sector, which now controls five of every six wetland acres in the United States. Developing a practical strategy for the preservation of privately held wetlands is a high priority task for all of us: the Service, the States, and the private sector. The ultimate solution must involve private landowners by providing them with incentives that effectively encourage retention of quality waterfowl habitats.

There are other problems that must be solved as we move ahead in implementation, e.g., subsistence hunting, fall and winter distribution of waterfowl as it relates to hunting opportunities among States, waterfowl feeding and the effect it may have on distribution and survival of waterfowl, depredation of crops and other damage and nuisance problems caused by waterfowl, and the role of hunting in regulating the size of populations. These problems may be less critical than the continuing loss of habitats, but they are no less demanding of our time and efforts on a day-to-day basis.

In the Fish and Wildlife Service our first step toward implementing the National Waterfowl Management Plan is, in fact, a late step in our overall planning process. We are currently incorporating waterfowl management plans into our Regional Resource Plans, which focus field level activities on important tasks. RRP's provide a practical way of setting in priority order our budgets and subsequent activities at the regional and field level. The species management plans that have been prepared previously give needed direction in the formulation of Regional Resource Plans. These Regional and field level plans will help insure that our ground level activities are in concert with the objectives and priorities to which we have all agreed at the National and international levels.

Our Regional Offices have been working closely with the States in the preparation of the first round of regional resource plans, and we expect to follow through with the same level of coordination and cooperation as we move to the implementation phase.

In summary, the National Waterfowl Management Plan for the United States provides general guidance that will come into full focus with the completion of flyway management plans. Service participation in implementing these plans is being effected through our migratory bird management activities and the Regional planning process. I am pleased with the spirit of cooperation demonstrated in waterfowl management planning, and am confident that a cooperative attitude will continue to exist as plans are implemented. And, finally, developing continental strategies with Bert Tétreault and Ing. Jesus Beruette Fuentes will, I'm sure, be a rewarding task.

Waterfowl Management Plans: A Canadian Perspective and Implementation Plans

B. Tétreault
Director General, Canadian Wildlife Service
Ottawa, Ontario

Before I start to tell you about the Canadian perspective on waterfowl management, I would like to mention two things. *First,* I want to say how impressed I am with this meeting. The Wildlife Management Institute is to be congratulated. It is not only because we have the opportunity to huddle together and to discuss mutual concerns. It is also because, so many of us, with so much in common, get the chance to really know each other. Ideally, I think that meeting this way is the best way to conduct business. Realistically, on this vast continent of ours, communication is not always easy. But when we go back to our respective offices, and communicate by letter or by telephone, we shall not be communicating with yet another faceless signature or voice. I am glad to have renewed acquaintance with so many of you whom I may count on as friends in the future. *Second,* although I have not registered this paper with the U.S. Department of Justice, I would like to formally announce my intention—as delegate of a foreign power—of trying to influence your thinking on waterfowl management by propaganda or other devious means of persuasion. However I shall not be using any audio-visuals. Nor shall I mention the forbidden subject: Acid Rain.

You know, Canada and the United States go back a long time as partners, as equal partners, in protecting and managing migratory birds, which our two countries are privileged to share. It was 67 years ago, in 1916—before most of us were born—that our two great nations had the wisdom and foresight to affirm the Migratory Bird Convention. Political considerations then, and ever since, have taken a back seat to consideration of the welfare of these birds. It is perhaps a shining example of how such bilateral cooperation can work. And the effectiveness of this 1916 Convention is very simply demonstrated. It is only necessary to compare the current abundance and distribution of migratory game birds with the dolefully depleted populations that survived prior to 1916.

Over the years, in Canada and the United States, the cooperation between our wildlife agencies has focussed mostly on waterfowl management. The federal, state, and provincial agencies, as well as the non-government organizations, have cooperated in a number of programs. Good examples are the Flyway Councils and Waterfowl Technical Committees. And currently we are sharing the joint evaluation of the effects of harvesting populations during the period of stabilized hunting regulations.

Yet there is a danger if we indulge in self-congratulation. Our cooperative ability to effectively manage the North American waterfowl resource in the future could be jeopardized by over-complacency. What we have now is only a foundation. We need to build on that base, to expand it and improve it.

And the most pressing requirement for joint action, lies in the protection and management of wetland habitat—which is being imperiled throughout the whole range of the North American waterfowl. This ominous threat to habitat was brought into sharp focus by then U.S. Secretary of the Interior Andrus and then Canadian Minister of the Environment Marchand in 1979. They called then for the development of a North American Waterfowl Management Plan by the Canadian Wildlife Service and the U.S. Fish and Wildlife Service. And, as a first step, both our countries undertook national plans which would eventually lead to a continental Plan.

In Canada, a final draft of our waterfowl management plan was recently circulated by the Minister of the Environment, John Roberts, to provincial wildlife ministers, asking for their endorsement. It is indeed a national plan, but it is not a federal plan. It has been produced through the cooperation of provincial, territorial, and federal wildlife agencies with considerable input from non-government environmental organizations. Our hope is to publish the final document in the very near future.

The three years used to carefully think through the Canadian Waterfowl Management Plan have been most productive. It was not simply an exercise to collate and organize existing information. It served us well as a stimulus to identify and debate many fundamental problems, and this led to logical actions to resolve these problems.

As you know, our two countries are democracies based on similar economic systems. However, there are significant differences in the distribution of powers below the federal level. In Canada, our constitution does not specify which level of government has jurisdiction over wildlife, and the provinces claim proprietary rights.

The federal government is presently responsible nationally and internationally for protection and management of migratory birds. This is a consequence of the 1916 treaty with the U.S. And it is interesting to note that in completing the Canadian Waterfowl Management Plan—as a first step toward the North American Waterfowl Management Plan—this exercise has provided a catalyst to table and debate some very different perspectives on the cooperative administration of the Migratory Birds Convention.

It has, inevitably, been elevated from discussions between wildlife administrators to a forum at the senior political level—an annual conference attended by ministers responsible for wildlife, from the provinces, territories, and the federal government. It has sparked interest in international waterfowl management and raised several issues that clamor for resolution.

Last September, the meeting of the Canadian wildlife ministers in Regina gave precise instructions to our wildlife officials. They gave us our marching orders.

1. The Canadian Waterfowl Management Plan was to be completed—and approved—in March 1983. Well, that date is upon us (and the job is done).
2. Develop a Canadian consensus to start a framework for discussion with the U.S. Fish and Wildlife Service, on a North American plan, by August 1983. That is only four months away. We are working on it—urgently.
3. Complete Provincial Waterfowl Management Action Plans and resolve federal/provincial roles and responsibilities by September 1983. That is just five short months left to resolve matters which have historically been left unresolved.
4. Make a start on developing the North American plan—together with the U.S. Fish and Wildlife Service—by January 1984. Significantly, that leaves us just

nine months for the gestation. It is good to know that our United States colleagues will be working with us at the delivery.

A short while ago I stressed the need for wetland habitat protection. Well, in the process of preparing the Canadian plan, we distributed one draft to a large number of non-government environmental organizations and individuals for comments. These reviews, provided by a wide cross-section of Canadians, were most impressive. They were supportive and offered constructive criticism. The only negative comments reflected local issues that could not be addressed in a national plan.

But the one overwhelming issue, stressed by this wide public response, was the urgent need to protect wetland habitat. This concern was, of course, expressed by hunters and their organizations. That was to be expected because they are knowledgeable about, and directly affected by, the destruction of habitat. But it was also the prime concern of a broad cross-section of Canadian Society, of Canadian citizens who had the foresight to understand the significance of such irretrievable loss.

And reinforcement for this broad-based concern, with the saving of wetland habitat, came recently when results of a federal/provincial socio-economic wildlife study were analyzed. So, the evidence is in. The concern for wetland habitat destruction is realized by a wide section of the public, and it must be considered the major issue facing North American Waterfowl Managers.

How do we in Canada plan to cope with the problem? Well, we can plan, we can regulate, and we can manage all we want, but unless we get our collective act together we will be whistling in the wind. Unless we protect our habitat base, our waterfowl resource is certain to decline. I anticipate that the North American plan—whose birth pangs we shall witness together next January—will identify a number of ways in which both government agencies and the private sector, in both our nations, can contribute to habitat protection and preservation. Meantime, the Canadian Wildlife Service is giving top priority to a program, based on new funding and administrative mechanisms, to provide national leadership in habitat protection. Our Minister, strongly supportive on this issue, will soon be taking a proposal to his Cabinet colleagues for a decision.

We in the Canadian Wildlife Service are hopeful that this program, when approved, will constitute a long commitment to habitat protection on behalf of the federal government. It will provide flexibility for the public and private sectors in Canada to cooperate fully in a variety of continental habitat protection activities.

All of us have a lot of work to do before the North American Plan is done. We recognize that it is a priority job, and to get the job done, on time and smoothly, we have appointed a full-time coordinator. Through an executive interchange program, we have been fortunate in obtaining the services of Dr. Sandy Macaulay who will be employed by CWS for the next 18 months as the Canadian Waterfowl Management Plan Coordinator. I do not think there is any need to introduce Dr. Macaulay to the waterfowl management community. He has already made quite a name for himself as chief biologist for Ducks Unlimited in Canada. I suspect he may be even better known when the North American plan is in place.

It may have seemed, at times, that the gestation period of the North American Waterfowl Plan was as long as that of an elephant. Well the good news is that the patient and child are in apparent good health. We all have to be prepared to labor at these final stages, but the prognosis is positive, and I think we may confidently expect a beautiful bouncing baby.

Provincial View of Waterfowl Management Plans

Ross MacLennan
Director, Wildlife Branch
Saskatchewan Department of Tourism and Renewable Resources
Regina

As Bert Tétreault indicated in his remarks, there is a momentum in Canada to tackle and complete waterfowl management plans at the provincial, national, and international level. I would like to give you three major reasons why this momentum exists and why I feel that waterfowl management plans will be completed and will be successful.

First, there is a feeling in many provinces that the costs and benefits of the waterfowl resource are not apportioned fairly. For example, in Saskatchewan at least 90 percent of the ducks we produce are harvested outside our borders, primarily in the United States. So, as you can see, we have a surplus of ducks in the provincial context. The migratory bird resource must be managed on a continental basis, therefore, we are under constant pressure to maintain or even increase the amount of ducks produced in Saskatchewan. As Director of Wildlife, I have a great deal of difficulty convincing the Saskatchewan Government to put more money and effort into waterfowl when we have shortages in other provincial wildlife, particularly big game.

If we want to raise ducks on a continental basis, we may well have to devise a continental funding system to produce enough birds. I would not like anyone to think that this is a radically new concept. Ducks Unlimited has operated on this principal for almost 50 years. They take money from the hunters in United States who benefit from the resource and put it into Canada where the majority of the resource is produced. Most provinces expect the North American waterfowl plan to address the problem of balancing benefits and costs.

The second major point that I would like to convey to the meeting is that there is a mood or feeling in Canada that it is time to review all aspects of waterfowl management, including resource needs, potential solutions, and roles and responsibilities of various agencies. Since 1916, many activities related to waterfowl have been identified and carried out by one agency or another. Habits have been formed. Not all these habits and activities have been efficient and productive, and some may no longer be necessary.

Some activities may be even negative or counter-productive. A good example of this was the season setting process that, for many years in Canada, required days and weeks of effort and usually resulted in frustration. Looking back I wonder how much was accomplished. Now we have a five-year harvest regulation and the time and effort that went into wrangling over season dates is being used constructively to solve other important problems such as habitat preservation and population dynamics.

One of my specific hopes for the waterfowl management plans is that a sound planning basis be used. The major pitfall in most plans is to get confused by activities. We get caught up in technical details without first defining the goals, principles, and objectives we are striving for. We must clearly define the problems that need resolution and the needs of the resource users. Once we know what the problems, needs, and some of our goals and principles are, we can delineate activities, roles, and responsibilities.

There is a general feeling in the provinces that provincial jurisdictions should handle waterfowl matters that are local in nature. These might include such things as licensing, enforcement, certain aspects of local hunting seasons, and delivery of crop damage programs. This does not mean that the federal government will not have a responsibility in funding these programs, but that the provincial government is the best agency to actually implement them. This approach would leave the federal government, particularly Canadian Wildlife Service, with more time to look after national and international items such as continental harvest apportionment and cost-benefit sharing.

The final point I would like to leave with the meeting is that the attitude in Canada has changed in recent years. Generally speaking, there is a much more cooperative, conciliatory attitude. Everyone recognizes there is a lot of work to do, enough for everyone to have part of the action. We want to get on with solving the problems, and we think we are all heading in the same direction, whether in the federal, provincial, or private sector. A considerable amount of credit must be given to the Canadian Wildlife Service, in particular to people like Bert Tétreault and Jim Patterson, who have changed the attitude in Canadian Wildlife Service from a somewhat defensive one about its role and mandate to a positive problem solving approach. It now seems nothing is cast in stone. New ideas are welcome, and the attitude is that all of us should be getting on with the job. I am confident that the provinces will respond with the same kind of attitude.

In conclusion, I think we are making progress. Momemtum is increasing. My prediction is that the plans will be completed on time or close to the scheduled deadlines. This does not mean that the plans will necessarily reflect the present status quo. When international negotiations start, don't be surprised if some new approaches are suggested! After all, it's almost 70 years since the 1916 agreement. Isn't it about time for a thorough review of waterfowl management and better mechanisms to achieve our joint goals?

Waterfowl Management Plans: Views of the International Association of Fish and Wildlife Agencies

Ted L. Clark
Chairman, Migratory Wildlife Committee
International Association of Fish and Wildlife Agencies
Austin, Texas

I welcome the opportunity to comment on migratory bird management in North America as a representative of the International Association of Fish and Wildlife Agencies and to be included in such a distinguished panel of conservationists. Certainly it is appropriate that the Association be included in such a panel representing as it does those conservation agencies which have made essential and substantial contributions to the management of these international resources.

The International Association was the crucible out of which the Flyway System of management was forged. Furthermore, the Flyway Council System has contributed to the marshaling of the considerable collective management expertise of two great nations, Canada and the United States, in a common goal: the conservation of North American migratory bird resources. Nevertheless, the attainment of this goal will not be achieved fully without the active participation by the Republic of Mexico, and we must be ever mindful of this fact.

Most of my comments will be directed at the philosophies contained in the National Waterfowl Management Plan for the United States, inasmuch as the Canadian plan has not been available for review. The Association, and the state conservation agencies it represents, wholeheartedly support integration of the Canadian and U.S. national plans, and subsequently a national plan for Mexico, into a waterfowl management plan for North America. The Association will avail itself of every opportunity to participate in the integration process.

In integrating the habitat management policies of Canada and the U.S., the member states of the International Association are most cognizant that Canada provides the overwhelming majority of the nesting habitat for North American waterfowl. Nevertheless, our Canadian colleagues must continue to recognize that the United States provides most of the wintering habitat essential to the welfare of the resources. Furthermore, in the protection of habitat in both countries, including the activities of Ducks Unlimited, we must be ever mindful that we do not create untenable depredation problems or modify the traditional distribution of waterfowl in such manners that we run the risk of losing the support of the agricultural community or of sportsmen.

Let us hope that the development of national waterfowl management plans by Canada and the U.S. will lead to closer coordination by the federal governments responsible for migratory birds in the respective countries. The decision taken by Canada in 1979 to stabilize waterfowl regulations for five years, in an effort to evaluate the relationship between hunting and total mortality, is a classic example of failure to coordinate on an issue of the utmost importance. The Canadian decision forced the U.S. Fish and Wildlife Service to hastily follow with stabilized regulations in the United States, which caught the Flyway Councils by surprise and largely circumvented the process by which regulations are developed in this country. Perhaps worse was the failure to adequately plan and coordinate the mechanism for evaluation of stabilized regulations prior to their implementation. As a result, there is some concern whether we will be able to conclusively determine if there is a compensatory relationship between hunting and non-hunting mortality at the end of the five-year experimental period.

Under the supremacy clause of the United States Constitution, only the Federal government may conclude treaties. Several treaties or amendments to treaties under consideration in recent years could drastically modify the principles of migratory bird management as we know them today. It must be remembered that once ratified, a treaty has the same effect as binding domestic law in the United States. For this reason, the International Association must be ever vigilant that accedence to any treaty purported to benefit international wildlife or their habitats has benefits accruing to wildlife of mutual concern to the United States. Treaties that are merely hortatory, which are poorly drafted, or which further erode state sovereignty over resident wildlife with no tangible benefits to migratory species must continue to be opposed by the Association. From all indications, the current Federal administration appears to be in harmony with this philosophy.

Admittedly, the issue of lead poisoning of waterfowl and its abatement is one of the most controversial to affect the conservation community in recent years. This controversy has resulted in the polarization of sportsmen groups and individual sportsmen alike. Amidst the controversy, the real issue often appears to be lost: the welfare of the international waterfowl resource.

Prompted by a desire to reduce lead poisoning in waterfowl, the U.S. Fish and Wildlife Service in 1976 initiated a non-toxic shot conversion program on a flyway-by-flyway basis with the support of the International Association. The conversion program was halted by the "Stevens Amendment" in 1979, which restricted the Service from exercising its authority under the Migratory Bird Treaty Act to mandate a ban on the use of toxic lead shot in hunting waterfowl. The Service retreated, effectively forcing the states to carry the full burden of the non-toxic shot conversion program if they deemed it necessary. Currently, 26 states support the mandatory use of non-toxic shot for hunting waterfowl within their borders. In an additional six states, non-toxic shot is required on national wildlife refuges only.

The U.S. Fish and Wildlife Service continues to take the position that lead poisoning of waterfowl should be alleviated whenever it is determined to be a significant problem. However, the Service's visibility under the current administration with respect to addressing the problem has been minimal. Highlights of their current position include: (1) the principal role of the Service will be to conduct research to better understand the lead poisoning problem (2) the effectiveness of steel shot has been adequately explored, therefore no further effort will be given by the Service to research this topic, and (3) the Service will serve as a clearinghouse for research and management information on lead poisoning.

Let us examine the Service's record of implementation of this position. First, since the states currently carry the burden of lead poisoning abatement, the Service should actively seek to counsel and coordinate with the Association to identify and initiate needed research. Second, if the Service feels the effectiveness of steel shot has been adequately explored, I would ask what conclusion they have reached.

Finally, the Service has failed to act as a clearinghouse for objective information on lead poisoning, requiring 26 states to form cooperatively with the National Wildlife Federation a national Lead Poisoning Control Information Program. To some it would appear the current federal administration is long on rhetoric and short on action in meeting its responsibilities with regard to alleviating lead poisoning of waterfowl.

On behalf of the Association, let me call for a more positive attitude on the part of the Department of Interior to join with the states to reduce these unnecessary losses of an international resource. These resources will not be well served by taking an inflexible position for or against either lead or non-toxic shot. Rational, not emotional, judgments must prevail; and if we err, let us err in favor of the resource for which we are responsible and dedicated to serve.

The Need for New Initiatives in Wetlands Management

Kenneth E. Brynaert
Executive Director
Canadian Wildlife Federation
Ottawa, Ontario

One of the primary difficulties with waterfowl management in Canada has been the absence of effective local involvement and participation in management planning and implementation. In the past, planning strategies have been developed and implemented on a broad scale, with emphasis on major projects, and very limited attention given to small wetlands development. Local involvement, if any, has been a minor consideration. As a consequence, numerous small wetlands, from a few acres to some substantial areas, have been lost or become degraded through lack of interest and attention. No concerted joint effort has been made to acquaint the public with the role and importance of small wetlands, in the context of their own local or regional environment, and to secure their support for preservation and enhancement activities.

The major threat to wetlands conservation is posed by agricultural drainage and by urban and industrial development. Examples of how small wetlands are affected by these activities, because they are not afforded proper protection, is demonstrated almost daily. Vast sums are expended annually by provincial agricultural agencies, supported by Department of Regional Economic Expansion (DREE) and Agricultural Rural Development Agency (ARDA) funds from the federal government, to plan and implement drainage programs. Often there is little, if any, consideration given to wildlife values that are destroyed through drainage projects. Many of the projects are of questionable economic value in terms of their cost/benefit, particularly when wildlife values are included in the equation. In many instances they could not be justified on their own merits alone, but a program is a program, regardless of the costs. It is time that all governments, federal, provincial, and municipal, took a hard look at the costs and impacts of their land drainage programs.

There is justification for the installation of tile drains to improve high quality agricultural soils and for ditching to carry away the spring run-off and heavy rains. However, the extensive so-called stream improvements, channeling and ditching, now practiced by agricultural interests virtually without restraint, are very much questionable, particularly when sub-marginal soils are involved. It is essential, *now,* to introduce appropriate measures that clearly place the onus on agricultural agencies to prove that drainage projects are economically viable and that they do not jeopardize our wetlands habitat.

To correct the problem, provincial governments must introduce legislation that clearly provides zoning protection for wetlands. This legislation must be imposed on regional and municipal governments, landowners, and government departments involved in land drainage and reclamation projects for agriculture, urban, and industrial development.

The onus must be placed on government departments, conservation authorities, and municipalities to clearly demonstrate that drainage and development proposals will not alter or degrade existing or potential waterfowl habitat. They must be required to initiate an approved environmental assessment and to include in their project proposal appropriate mitigating and remedial measures for the preservation and enhancement of wetland habitat. It is also essential to provide appropriate protection for stream and river corridors, and to remove these areas, once and for all, as options for urban and industrial development.

Rural zoning regulations to protect and preserve wetlands habitat must also be made fully applicable to private and corporate landowners. The fact of ownership should not carry the right to permanently alter the character of the land or to arbitrarily change its function. Permits for clearing, draining, and other major alterations must be made a firm requirement in the same way that permits for water control structures are now needed. This is the only way we can ensure the proper protection and management of wetlands habitat. It is amazing that people become so emotionally involved with issues, like the east coast seal harvest, for instance, but remain totally silent when wildlife are dispossessed by habitat destruction.

Wetlands by nature are the most vital element in the effective management of waterfowl, but a large number of other wildlife species also depend on this habitat type. Whether one is a hunter, a naturalist, or just enjoys the presence of animals and birds, the preservation and enhancement of our wetlands is an objective that should appeal to one and all.

Participation and support is needed now. The development of a national waterfowl management plan is no doubt a worthwhile effort. But, its success will only be measured by the extent to which people and governments become involved.

Response to Canadian and United States Discussion of Waterfowl Management Plans

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Although the program lists me as a representative of The Wildlife Society, I would like to disclaim that role, because it is doubtful that any one person could adequately represent the collective thinking of the Society on this subject. Please consider my brief remarks as those of a long time member of The Society (over 30 years) and someone vitally interested in this Continent's waterfowl resources.

I am most appreciative of this opportunity to comment on some aspects of the national waterfowl management plans. I firmly believe that a North American waterfowl management plan is essential to the future of waterfowl and waterfowling on this Continent. There are, however, some concerns about the planning process. Development of any such planning process should be vitally concerned with the feasibility of implementation. Since 1979 the Mississippi Flyway Council has been trying to work with a management plan for the Mississippi Valley population (MVP) of Canada geese. Only recently the MVP Committee of the Mississippi Flyway Council scrapped the plan, primarily because it was virtually impossible to implement. The Council is now going back to the drawing board to develop (hopefully) a plan that will have a better chance of accomplishing its purpose. This illustration is given to emphasize the need for rational and responsible thinking and careful consideration of all aspects of a problem in the planning process; and not to be critical of any agency or individual.

We now have a national waterfowl management plan, and there are proposals for flyway plans, species plans, and population plans. Somewhere in this process we would hope that there is some room for "doers" as well as "planners." In recent years we seem to have become victims of the "planning process." We develop plans to the tune of tons of paper, and that is where many of them end. Let us hope that waterfowl management plans are not destined to this same fate. If they cannot be developed and implemented in a most expeditious manner, it may be too late. If we are not careful, we may still be planning in the year 2000 while the resource is still slipping away.

I am concerned about changing habitat, certain management activities, and the resultant changes that are occurring in migrational patterns of waterfowl. In the past 25 years we have seen drastic changes in migration patterns of mallards and Canada geese and, more recently, lesser snow geese. These changes have unquestionably been brought about by habitat alteration and changing agricultural harvesting practices in large part. However, there is evidence that intentional management practices on state and federal refuges have also played a part in the development of current problems. The chronology and magnitude of mallard migrations to southern wintering habitat have been altered substantially, and Canada geese have almost totally abandoned some traditional wintering habitat. Fifteen years ago, when it was brought to the attention of Canadian Wildlife Service and

U.S. Fish and Wildlife Service authorities that the traditional migration patterns of lesser snow geese were being altered, the response was that "this is more speculative than real." We are now faced with the reality that the wintering populations of lesser snow geese on traditional wintering grounds on the Northern Gulf Coast have decreased by about two-thirds. Planning will not reverse this trend, action may.

Historically, major interest in waterfowl habitat has centered around breeding grounds, and this is likely as it should be. However, with the drastic changes that are taking place on the wintering grounds, a new approach may be indicated. Bottomland hardwoods, the core of wintering habitat for mallards and wood ducks in the Mississippi Flyway, have virtually disappeared. They won't wait another ten years for development of planning strategy. Coastal marshlands in Louisiana, a most important state for wintering waterfowl in the Mississippi and Central Flyways, are disappearing at an alarming rate—40 square miles (103.6 km^2) per year from erosion and subsidence. Winter habitat in other flyways is apparently suffering from different but equally disturbing influences. We suggest that every agency, public and private, with an interest in waterfowl resources may be well advised to take a hard look at winter habitat and be prepared to assist in this vital link in the well-being of waterfowl, and that any planning process take cognizance of this problem and address it in an appropriate manner.

One other note, if everyone involved is not totally committed to any plan, it likely has a dismal chance of success. I suggest that we move forward rapidly with the development and implementation of the North American plan.

Monitoring Fish and Wildlife Populations: State of the Art

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Introduction

Mandates for monitoring wildlife and fish resources derive from the legal responsibilities of State and Federal agencies to protect, conserve, and restore populations and habitats. Fulfilling these responsibilities requires monitoring, that is, the acquisition of information that allows an evaluation of accomplishments.

According to Webster's *New Collegiate Dictionary,* monitoring is the process of observing or checking—measuring—in order to regulate or control the operation of something. The something in this case is usually a plan or program for meeting natural resource objectives. Thus, wildlife and fish monitoring can be considered to be the collection and interpretation of population or habitat data, or both, to evaluate progress toward meeting objectives (attainment) and indicate needed adjustments in the course of management (feedback). The control aspects of monitoring, that is, feedback to indicate attainment or needed adjustments, form the major distinction between monitoring and inventory.

Resource inventory is the compiling of information on the kinds, amounts, and characteristics of physical and biological elements needed to plan and manage an area or resource. Inventory information and methods can be used in monitoring. But, the purposes of inventory—a listing of things—and monitoring—an evaluation for feedback on objectives—are different. Inventory supports resource plan development, whereas monitoring indicates management attainment and supports resource plan adjustments. Inventory will often encompass measurement of many things. Monitoring should be specific to plan objectives and major assumptions used in planning.

This paper presents some aspects of biological monitoring—the legal requirements for different agencies to monitor wildlife and fish, monitoring as a management tool, and conceptual models for population and habitat monitoring.

Legal Requirements For Monitoring

Numerous laws and regulations guide monitoring activities of State and Federal agencies. Though there were some historical antecedents, most of the significant Federal agency requirements derive from the National Environmental Policy Act of 1969.

The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321–4347). The NEPA, as amended, declared a national policy to "encourage productive and enjoyable harmony between man and his environment," and "to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man. . . ." It established a Council on Environmental Quality, which included in its regulations to implement the national policy: "Agencies may provide for monitoring to assure that their decisions are carried out and should do so in important cases" (40 CFR 1505.3).

In furthering the purpose and policy of NEPA, Executive Order 11514, March 5, 1970, as amended by Executive Order 11991, May 24, 1977, on Protection and Enhancement of Environmental Quality, assigned responsibilities to the heads of Federal agencies to "Monitor, evaluate, and control on a continuing basis their agencies' activities so as to protect and enhance the quality of the environment" (Sec. 2(a)). It also instructed the Council on Environmental Quality to "Promote the development and use of indices and monitoring systems (1) to assess environmental conditions and trends, (2) to predict the environmental impact of proposed public and private actions, and (3) to determine the effectiveness of programs for protecting and enhancing environmental quality" (Sec. 3(e)).

Certain agencies are also guided by earlier legislation and other authorities.

The Migratory Bird Treaty Act of 1918 (16 U.S.C. 703–711). The Act, as amended, implemented the 1916 migratory bird conventions between the USA and Great

Britain for Canada. It established a Federal responsibility for the protection and controlled taking of migratory birds. Subsequent amendments have been made to implement the migratory bird treaties with Mexico (1930), Japan (1974), and the Soviet Union (1978). The act called for the coordinated protection and management of migratory birds and their habitats, thus periodically requiring various kinds of resource information useful in adjusting management programs.

The Fish and Wildlife Act of 1956 (16 U.S.C. 742a–742). The Act, as amended, is a national fish and wildlife policy and is often referred to as the USDI Fish and Wildlife Service's "Organic Act." Among other things, the Act directed the Secretary of the Interior to ". . . conduct continuing investigations . . . and make periodic reports to the public, to the President, and to Congress, with respect to the . . . availability and abundance and the biological requirements of the fish and wildlife resources."

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531–1543). The ESA, as amended, provided for the conservation of threatened and endangered species of fish, wildlife, and plants by Federal action and the establishment of State recovery programs. Specific provisions authorized the determination and listing of endangered and threatened species and the range over which such conditions exist. Monitoring is needed to determine progress under the Act.

The Multiple Use and Sustained Yield Act of 1960 (MUSY) (16 U.S.C. 528–531.) The MUSY established management of National Forests and their resources on the basis of multiple use and sustained yield to meet both present and future needs of the American people. Accomplishing this requires periodic and systematic inventories of the lands and their resources, including fish and wildlife. The Secretary of Agriculture is responsible for keeping inventories current to reflect changes in conditions and to identify new resource values.

Federal Land Policy and Management Act of 1976, as amended, 43 U.S.C. 1701 et seq. The Act established management of public lands and their resources on the basis of multiple use and sustained yield to meet both present and future needs of the American people. One way this is accomplished is through periodic and systematic inventories of public lands and their resources, including fish and wildlife. The Secretary of Interior is responsible for keeping inventories current to reflect changes in conditions and to identify new resources values. In addition, land use inventory, planning and management activities should be coordinated with similar programs of other Federal agencies, and State and local governments.

The Forest and Rangelands Renewable Resources Planning Act of 1974 (RPA), as amended by the National Forest Management Act of 1976 (NMFA) (16 U.S.C. 1600–1614). The RPA directed the Secretary of Agriculture to "make and keep current a comprehensive survey and analysis of the present and prospective conditions of and requirements for the renewable resources of the forest and rangelands of the United States. . . ." This information will be used to periodically revise the national forest and rangeland resource program.

The NFMA regulations for planning National Forest management (36 CFR 219) require a program of monitoring and evaluation. Forest plans will be revised at least every 15 years, or sooner when necessary. The monitoring and evaluation process is the mechanism for recommending revisions at any time. Each plan will have a specific set of monitoring actions to evaluate, on a sample basis, how well objectives have been met and how closely management standards and guidelines have been applied. Specific to wildlife and fish, population trends of management indicator species will be monitored, and relationships to habitat changes determined. The monitoring will be done in cooperation with State fish and wildlife agencies to the extent practicable

The Soil and Water Resources Conservation Act of 1977 (RCA) (PL 95–192). The RCA directed the Secretary of Agriculture to "appraise on a continuing basis the soil, water, and related resources of the Nation" and to develop a national program to guide the Department's future soil and water conservation activities on the Nation's private and other nonfederal lands. The program is based on the appraisal and projected resource needs. Once the program is in place, the USDA will conduct continuing evaluations to ensure that all of its conservation activities are effective in meeting objectives. Each agency with program responsibilities will evaluate the specific program for which it is responsible. For example, the Soil Conservation Service will evaluate the effects of conservation technical assistance and the resultant change in land cover on wildlife habitat.

The Coordination Act of March 10, 1934, as amended to become the Fish and Wildlife Coordination Act (FWCA) (16 U.S.C. 661). The FWCA authorized and directed Federal and State agencies to jointly study the effects of certain water development projects and to recommend fish and wildlife measures to protect or enhance the habitat of the species involved.

The Sikes Act (Act of September 15, 1960, as amended, U.S.C. 670g). The act provided for "the Secretary of Interior and the Secretary of Agriculture, in cooperation with State agencies, to establish programs for the conservation and rehabilitation of fish and wildlife on public lands." Before lands are developed, studies and surveys are made to determine where conservation and rehabilitation programs are needed. The act identified methods and procedures such as census, research, and habitat management for establishing programs to "protect, conserve, and enhance wildlife, fish and game resources on public lands."

A State Agency; Colorado Division of Wildlife

The Colorado Division of Wildlife's legal requirements for monitoring are similar to those of other States in that they derive primarily from statutory authority and the responsibility to manage resident wildlife resources. "The [Colorado Wildlife] Commission is responsible for licensing requirements and the promulgation of rules, regulations, and orders concerning wildlife programs. The Commission shall establish objectives . . . which will enable the Division of Wildlife to develop, manage, and maintain sound programs of hunting, fishing, trapping and other wildlife-related outdoor recreational activities" (33-1-108 (1) and (2) C.R.S. 1973). Monitoring performance relative to objectives is particularly important in the areas of hunter satisfaction, harvest regulations, habitat improvement, environmental protection, and stocking.

Summary of Legal Requirements

Legal mandates to monitor derive from a variety of laws and regulations. They range from rather nebulous requirements to collect and maintain information on resource status to specific instructions to use information from monitoring in a process of plan revision. The former tend more toward the earlier definition of inventory, and the latter are more in tune with Webster's definition of monitoring as part of a control mechanism. We next examine some implications of monitoring requirements, and concepts for efficiency in monitoring.

Monitoring as a Management Tool

Monitoring as a Feedback Process

Monitoring provides resource managers with feedback on the accuracy of their knowledge and the effectiveness of their actions (Faludi 1973:279). Holdgate and White (1977) discussed monitoring as the systematic collection of data needed for environmental problem solving. It is useful in at least three resource management tasks (Crumpacker and Ervin in prep.): (1) testing the adequacy of impact predictions and mitigation recommendations (Holling 1978), (2) revising management strategies (Holling 1978), and (3) generally making better resource management decisions (National Research Council 1977).

There are four principal steps in a monitoring program: (1) set objectives, (2) identify actions and impacts to be evaluated, (3) collect data and analyze, and (4) evaluate results. Objectives must be feasible, and the actions and impacts to be evaluated must be directly related to the objectives. Data collection, analysis, and evaluation are not so straightforward.

To be effective, monitoring should include measures of existing conditions to allow comparison with the effects of management. The effects to be measured should include the key variables that are identified as resource objectives, environmental standards, or indicators of land health and productivity. In some cases it may be necessary to monitor the source (causes) of environmental changes (e.g., harvest activities, vegetation management projects). Monitoring is also important in the general refinement of knowledge and assumptions used in planning future resources.

The above points show that monitoring is considered as both an activity (measuring) and a process (evaluation and refinement). As an activity, monitoring, like inventory, is the collection of data subject to assumptions, management objectives, sampling efficiency, and budgets. As a process, it is the evaluation and use of the data as feedback to improve decision making. It is in this latter sense that monitoring transcends inventory to become a vital link in the cycle of adaptive resource management (Holling 1978).

Monitoring can be viewed as a part of applying the scientific method to resource management (Figure 1). Hilborn and Walters (1982) noted that well-designed monitoring studies using control areas allow the use of resource management activities as experiments, thus leading to increased knowledge and understanding. Management prescriptions to meet objectives, that is, sets of practices or actions, can be viewed as management hypotheses (the oval in Figure 1). Measurement of their efficacy when applied to real land units constitutes a test of the "hypothesis" (the dashed lines flowing to the evaluation filter in Figure 1). Evaluation of the test leads to refinement of knowledge (the dashed line flowing to the level of new knowledge in Figure 1). It can also indicate the need to formulate a different hypothesis, i.e., change the prescription and course of management. Such revision occurs in the next time interval of the model in Figure 1: the new knowledge level

THE ACTIVE ADAPTIVE MANAGEMENT SYSTEM

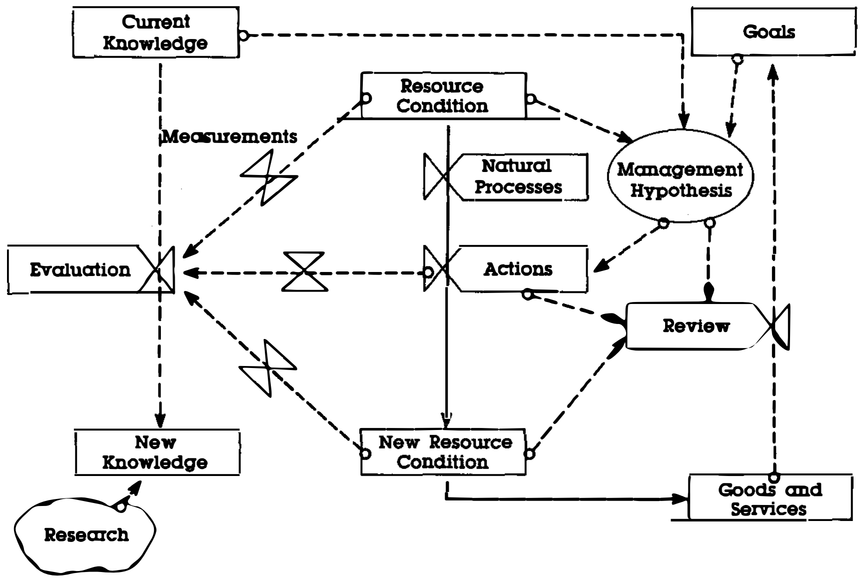

Figure 1. The feedback role of monitoring in a cyclic, adaptive resource management process.

becomes current knowledge, the new state of resources becomes the current state, and the new goals are formed on the basis of satisfaction with old ones and changing demands. To capitalize on the opportunity to use monitoring in such a feedback process, people with expertise in experimental design and statistical inference should be cooperators in monitoring programs.

Monitoring in Relation to Decision Risk

Monitoring is important, but only one part of resource management; it commands only a part of the limited management budget. This presents policy and methods problems in implementing a monitoring program: (1) how reliable must the projections and measurements be—how much of the budget should go to monitoring; and (2) who will collect and interpret the data?

For efficiency, monitoring studies should be designed within the constraints of specific objectives, major assumptions, the resources at hand, and statistical concerns. Criteria for adequate measurement and estimation of variables in monitoring have not been well established in general use. Moore and Mills (1977) suggested confidence limits of 80 to 90 percent for detecting a 10 to 20 percent difference between parameter means. The reliability levels of statistics used in monitoring should depend on at least three factors applied on a case basis: (1) the decision risk, i.e., the "cost" and likelihood of being wrong in the projected effect (this can also be viewed as the expected value of perfect information), (2) the natural variation in the parameters to be measured, and (3) the technology and resources (people, time, and money) available to measure the key variables. These points can be put in the context of tying monitoring expenditures to the expected value of perfect information (Figure 2).

All decisions about natural resources are made under uncertainty (Walters and Hilborn 1978). This uncertainty can be viewed as the consequences (costs) or foregone opportunities of a projection being incorrect. One can also say that all resource projections and measurements are uncertain. For example, the confidence interval around a point estimate of a population statistic is a statement about our certainty (or uncertainty) that the measure is the true population value.

Logically, the higher the "cost" due to an incorrect projection (higher expected value of perfect information), the higher should be the reliability of projections and measures of the intended results. For example, the cost of incorrectly projecting future populations of grizzly bear, elk, summer run steelhead, or any other socially, biologically, or economically important wildlife or fish resource are high. These values justify relatively high expenditures to minimize the uncertainty in projections and our knowledge of population status and trends and the key factors affecting the populations.

Using the general rule portrayed in Figure 2, investments in monitoring should

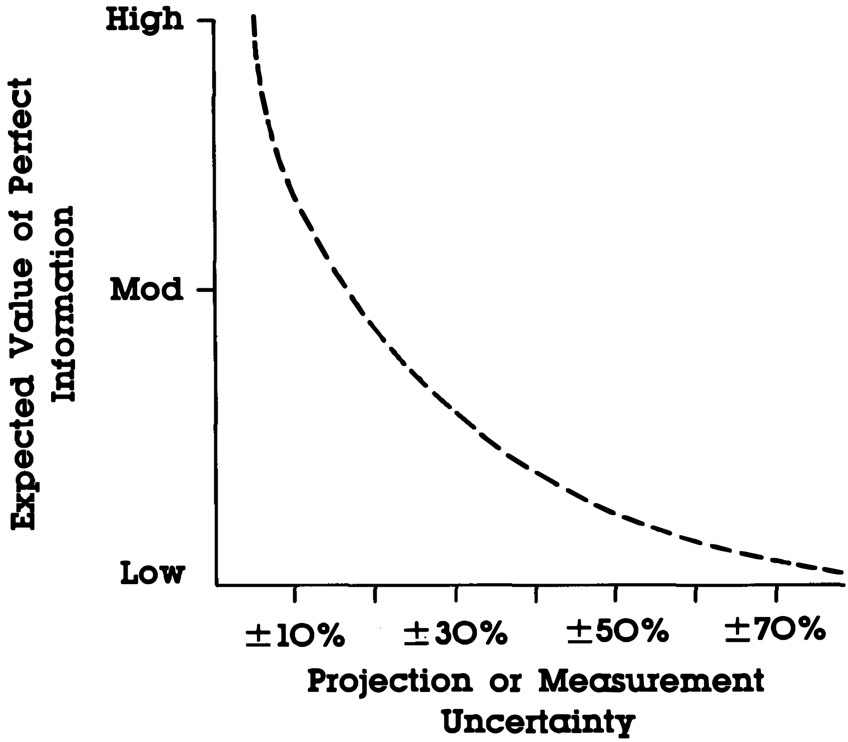

Figure 2. The general relationship between decision risk and the corresponding need for reliability in monitoring statistics.

reflect both the potential "costs" of a wrong decision and the probability of the decision being wrong. If inadequate technology, natural random events, or lack of personnel and dollars prevent the acquisition of accurate and precise data on a highly valued resource, then decisions should be conservative and include monitoring activities appropriate to the decision risks.

The feedback and decision-risk aspects are but two of the important considerations in monitoring. They are sufficiently important though, that they set a contextual framework for monitoring strategies and activities.

Conceptual Models For Populations and Habitat Monitoring

Organizations and individuals responsible for fish and wildlife management often debate the question: What should be monitored, populations or habitats? We submit that to understand what is actually happening, information is needed on both. Although it is easy to take a simplistic view of the world and argue that trend information on either habitat conditions or populations is adequate for management, one will often overlook indirect causes and interacting factors. Patten (1982) noted that conventional assessments focus on direct causes and that by ignoring the importance of indirect causes one is, in fact, overlooking the importance of ecosystem interactions. It is easy to say that wildlife is the product of the land and thus it is more important to inventory the habitat than population levels. However, this approach fails to recognize the effects of non-habitat factors on populations and the effects that wildlife populations often have on their habitats. A failure to look at the species and its habitat as a system, as pointed out by Patten (1982:93), is ". . . an outgrowth of a deep philosophical separation of the organism from its environment." A dissection of species from habitats (or vice versa), while appealing on the surface for various administrative and other reasons, must be recognized as artificial. In reality, animals and their habitats operate as a functional unit. A monitoring program which focuses solely on either habitat or species is incomplete in the long run and will fail to detect underlying cause and effect relationships.

Population Monitoring

Data collection for population monitoring begins with a decision on what data to collect. This decision is best made by working backwards through the monitoring process. The manager begins by considering the objective against which performance is to be monitored and determining what kind of information is necessary (e.g., if the objective is expressed in terms of population trend, it is not necessary to gather information about population size or composition). The next consideration is what analysis techniques are available to provide the necessary information. Finally, the data needed for each analytic procedure are considered. Tradeoffs must inevitably be made between the desired reliability of information to be obtained and the cost of obtaining it. Once a decision is made on what data to collect, the actual data collection operation is usually well understood.

Data analysis is necessary because we often cannot collect the specific data needed (i.e., it may not be feasible to conduct a census count of an elk herd for which a population objective has been set) and because the data we can collect are frequently less precise or accurate than desired.

The first problem can be solved by the use of indirect estimators (e.g., change-in-ratio or capture-recapture analyses to estimate populations) or the use of trends in harvest success as an indicator of population trend. The second problem may be solved by averaging two or more independent estimates of the desired population parameter. The use of a population simulation model to fit a set of observed data is one way to address both problems simultaneously (Pojar 1981).

Finally, the evaluation of results compares observed performance to the previously established objective, leading to appropriate modifications of management programs, future objectives, or both. Gill et al. (1983) and Van Deventer and Platts (1983) provide excellent overviews of approaches to population measurement.

Habitat Monitoring

Habitat monitoring also uses the same four-step general monitoring process. This discussion focuses on the possible role of habitat models in habitat monitoring. Many technical approaches have been developed to monitor habitats. The concept presented here used species-habitat relationships models as evaluation tools. Such models are a form of wildlife production function (Giles 1978). They are being developed and tested by several agencies and universities: Habitat Suitability Index (HSI) (Schamberger and Krohn 1982, Cole and Smith 1983), Habitat Capability Model (Nelson and Salwasser 1982), and PATREC (Russell et al. 1980) are examples. A scenario for their use in habitat monitoring follows.

An objective for habitat capability for a species would be set and expressed as a proportion of potential habitat capacity (e.g., an index) or the number of individuals the habitat in an area is potentially capable of supporting. A species-habitat production function model, like an HSI, would be used to identify the habitat variables that are most important in producing the population, or most highly correlated with the production factors, and that will be affected by management. These habitat variables will both be expressed in management objectives or standards and be the factors to be measured.

To make population inferences using species-habitat production functions, it is necessary to calibrate the models empirically. This involves statistical comparison of model-based habitat evaluations with data on the species in an area. Such a test indicates the reliability—accuracy and precision—of the model. Lancia et al. (1982) provided an example of a model test. Marcot et al. (1983) discuss model validation criteria. Management actions can also be set up as "experiments" to further test habitat relationships models following the left column in Figure 1.

With a locally or regionally calibrated species-habitat production function, inventories of the key habitat variables can be used in a monitoring program to make inferences about population objectives. Future inventories can be evaluated with the model to estimate habitat capability and the range of potential population levels based on model reliability.

Summary of Conceptual Models

The use of models in both population and habitat monitoring is necessary because we cannot always obtain the desired data at acceptable levels of accuracy and precision. As with monitoring in general, the use of models should employ the feedback concepts of adaptive management. This is illustrated by Figure 3, which is a more detailed representation of a part of Figure 1.

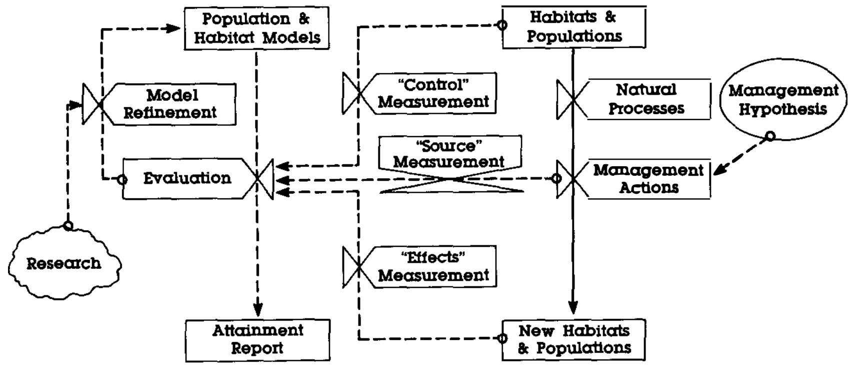

Figure 3. A conceptual model for wildlife and fish monitoring using species-habitat production functions or population models.

The flow of information from measurements of initial and managed resource conditions are seen as the control and effects aspects of monitoring, respectively. Measurements of management actions are source monitoring. Evaluation of these measurements with population or habitat models allows efficiency in attainment reporting and the refinement of the models. That refinement is equivalent to obtaining a new level in the state of knowledge, as shown in Figure 1. The role of research in this refinement is indicated by its representation as a source of new knowledge that must enter the management loop through the upper left box. It is critical to our earlier discussion to recognize the importance of the management experiment aspect of monitoring as an additional source of new knowledge.

Conclusions

It is clear that monitoring wildlife and fish is a critical part of natural resource management. It is also clear that inventory alone does not constitute monitoring. Monitoring is measurement and evaluation used in an incremental process to measure attainment and facilitate adjustments in assumptions, objectives, or management actions. To be most effective in fulfilling its management role and in contributing to our knowledge, monitoring activities should use experimental design principles. Reliable measurements and evaluations are crucial to adaptive resource management. This indicates a need for cooperative work between managers and researchers.

Species-habitat relationships models and habitat and population simulation modeling hold promise for augmenting information derived from empirical studies. Widespread use of such models will gain credibility and value in direct proportion to the extent that they are tested, that is calibrated, with real population data, and applied within the geographic range of their validity. Researchers and managers need to cooperate on these studies and their application in monitoring, as Verner (1983) has proposed.

Acknowledgements

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Monitoring Regional Wildlife and Fish Habitats and Populations For National Assessments and Appraisals

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Introduction

The Forest and Rangeland Renewable Resources Planning Act (PL 93-378) of 1974 (RPA) and the Soil and Water Resources Conservation Act (PL 95-192) of 1977 (RCA) require the Secretary of Agriculture to conduct assessments and appraisals of wildlife and fish resources together with other renewable natural resources. The USDA Forest Service (FS) released assessments of the wildlife and fish resources on the nation's 1.7-billion acres (688.5-million ha) of federal and nonfederal forest and range lands in 1976 and 1980 (USDA Forest Service 1977, 1981), subsequent assessments are required every 10 years. The USDA Soil Conservation Service's (SCS) appraisal of the soil, water, and related resources of the nation, including wildlife and fish habitats, was completed for the 1.5-billion acres (607.5-million ha) of nonfederal land in 1980 (U.S. Department of Agriculture 1981); a second appraisal is due in 1985.

RPA assessments and RCA appraisals are national mechanisms for monitoring the natural resource situation. Monitoring requires successive inventories of resource production and use to evaluate how accurate projections of resource availability and use have been and how successful resource management plans have been in meeting quantified objectives. The analyses for assessments and appraisals of wildlife and fish include (1) inventories of current land and water area, wildlife and

[1]Work on this project was carried out while Miller was an Intergovernmental Personal Act Assignment with the USDI Fish and Wildlife Service and stationed at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

fish populations, and production capability of habitat; (2) projections of resource inventories and use; and, finally (3) implications and opportunities for improving the current situation through alternative land and resource management programs. This paper reports on the data and regional analyses that are being assembled and developed to support each of these three activities in the 1989 National RPA Assessment and RCA Appraisal.

Current Inventories and Use of Wildlife and Fish

Wildlife and fish resources have been measured in terms of both habitats and populations. There have been few consistent nationwide inventories of either habitats or populations (Hoekstra et al. 1979), and what inventories do exist are currently inadequate. The review of wildlife habitat inventories by Hirsch et al. (1979) noted: "In the current National appraisals by the Soil Conservation Service and Forest Service, 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 is still the case in 1983. Hirsch et al. (1979) recommended that, to develop a coordinated federal-state effort, the International Association of Fish and Wildlife Agencies assign a committee to work with federal agencies through the Interagency Agreement Related to Classification and Inventories of Natural Resources. The recommendation was implemented, but it failed, partly because no current definition of wildlife habitat is consistently useful to both state and federal agencies.

Resolution of the habitat definition problem is not imminent, although progress is being made. The FAO North American Forestry Commission's Wildlife Study Group is evaluating various definitions used in analytical models, land classification systems, and inventories by comparing them to a definition based on ecological theory. The study group is to report to the North American Forestry Commission in early 1984 on whether existing land classifications are adequate and whether a North American wildlife habitat classification should be developed. Canada, Mexico, and the United States have technical working groups assigned to this task.

Wildlife population estimates are derived from direct inventories of animals themselves and from other measures of the animals or their habitats. As a result, the estimates are diverse in kind and quality; most were developed for specific local purposes.

For the 1989 RPA Assessment and RCA Appraisal, the data bases used in 1980 are being revised and updated to reflect analyses of current habitat and population inventories. The objective is to establish a county or management unit-level data set for terrestrial and semiaquatic vertebrates and a watershed-level data set for fish species.[2] The Forest Service, Soil Conservation Service, Oak Ridge National Laboratory, and the states of Colorado, Wyoming, Kansas, Nebraska, and North and South Dakota are cooperating in a pilot test to compile current harvest inventory and consumptive use information through the Land and Resource Management Planning Research Project (LRMP), Rocky Mountain Forest and Range Experiment Station. This data set will include a complete fish and wildlife species

[2]Watersheds will be used in Alaska for both terrestrial and aquatic analyses and data compilation.

list, with available population and/or harvest estimates supplied by state wildlife and fish agencies.

For terrestrial and semiaquatic species, the habitat information will include the number of acres classified by land use, land cover (including water system), and vegetation structure and productivity. The Forest Service's continuous Forest Inventory and Analysis units (USDA Forest Service 1982) and the Soil Conservation Service's National Resources Inventory (USDA Soil Conservation Service 1982) will be the primary sources for habitat data. Other data, such as those provided by the National Wetland Inventory (Montanari and Townsend 1976), will be used if they are compatible with the Forest Service and Soil Conservation Service inventories.

For fish, the habitat data base will include information on temperature, flow, turbidity, nutrients, and toxic loads from reservoir, lake, pond, and stream locations. These water quantity and quality data will be acquired from extant sources such as the U.S. Geological Survey WATSTORE system (USDI Geological Service 1975), the Environmental Protection Agency STORET system (Environmental Protection Agency 1979), and state water resource agency files.

Upon completion of the county-and watershed-level data bases, regional (multistate) tabular summaries will be developed by the LRMP to satisfy the first requirement of the Assessment and Appraisal. These summaries include the number of vertebrate species, average current population levels and/or harvests for selected vertebrate species, acres of terrestrial and semiaquatic habitat, and miles or acres of fish habitat. Also, species lists are being compiled for all forest, range, and agricultural cropland.

Projections of Inventory and Use

The next requirement is to predict supply and demand. For wildlife and fish, this is interpreted as projections of inventory and use because traditional economic definitions for supply and demand are based on a market structure that generally does not exist for these resources.

The projections of inventory and use will provide insight into possible future imbalances between resource supply and demand. Therefore, in the future, resources should be analyzed in consistent terms, e.g., quantity of animals produced or supplied and quantity of animals used or consumed. Unfortunately, for most species production and consumption figures are available only in acres of habitat and recreation visitor days, respectively. The LRMP contends that the animals themselves are the resource and, to the extent possible, should be the units used in both analyses. The analysis and research described below is directed at developing methods that describe the resource in a consistent manner (e.g., animal units) for both inventory and use projections.

The wildlife and fish habitat-based population model should be correlated with variables in other land or resource models. This is important for three reasons: (1) it is necessary to evaluate production interactions (competing land uses); (2) there are few national inventories of wildlife habitats or populations; and (3) there are no economic models for how nonmarket resources are expected to be produced in the future. Therefore, a method of land area or market resource projection is required from which future wildlife and fish inventories can be extrapolated.

The land area projection method has the most promise in that it could project variables such as land use, land cover, and surrogate variables for vegetation structure. To the extent that land use, cover, and vegetation structure variables are related to wildlife habitats and populations, wildlife inventories can be interpreted from the land area projection.

The Forest Service and Soil Conservation Service anticipate that the research study on land area projection will provide information on expected acreage classes of the land use, land cover, and vegetation structure variables. These agencies are carrying out cooperative studies to develop and evaluate analytical methods, which can be linked to land area projection methods for predicting regional wildlife and fish populations and habitats. Multivariate statistical analyses (primarily discriminant function) will be used to correlate wildlife population or harvest levels with land use, land cover, and vegetation structure variables (Kitchings and Klopatek 1981). Data for counties or species management units are being used for estimating regional population or harvest levels. In a pilot test, discriminant function models are being run with 1977 data. The models are also being tested with 1966 and 1982 data. If the method performs satisfactorily, the models for the 1989 Assessment and Appraisal will use 1986 data to make inventory projections.

For projecting fish habitat and populations, the analytic method is not currently defined. The Forest Service's LRMP Research Project, in cooperation with Oak Ridge National Laboratory's Environmental Sciences Division, are developing and evaluating analysis methods and data. The objective is to examine existing data on fish populations, water quantity and quality, and analysis methods that will permit regional projections.

Wildlife and fish use is defined as a result of three methods as: (1) commercial value, (2) recreational value, and (3) existence value.

For commercial fish species or fur-bearing animals, for example, a traditional competitive market structure is appropriate for projecting consumption or use. Considerable effort will be required, however, to develop supply-demand equilibrium models for evaluating these market resources.

Except for state license fees, recreation uses have traditionally been provided free on public lands and either free or for an access or trespass fee on some privately owned areas. Because these uses are available independent of price, the traditional market structure is an inappropriate basis for projections. As a result, the actual expected consumption would be a sustained disequilibrium. Thus, to project recreation consumption, a structure such as the following can be used in the next national assessment and appraisal:

$$Q_c = F(P, X_i, Q_p)$$

Where:

Q_c = quantity of wildlife or fish resources actually consumed,
F = consumption function,
P = price surrogate such as travel cost,
X_i = traditional demand shifters such as income, and
Q_p = quantity of wildlife and fish resources provided.

An important implication of this structure is that the quantity consumed or used is influenced by the quantity supplied. If a public agency is to use projections of the quantity consumed to anticipate overuse, then the effect of decisions on the development of wildlife and fish populations or habitats must be taken into account.

For a more detailed discussion of this approach applied to recreation resources, see Hof and Kaiser (1983). The Idaho Department of Fish and Game, USDA Forest Service, and USDA Soil Conservation Service are cooperating in a research study estimating recreation values of wildlife and fish, through the Valuation of Wildland Resource Benefits Research Project (VWRB), Rocky Mountain Forest and Range Experiment Station.

Existence values of wildlife and fish represent the least understood "use" of the resource. It recognizes that some people place a value on just knowing that wildlife and fish exist somewhere, even though they never intend to use them directly either consumptively or nonconsumptively. This value of the wildlife and fish resource has been recognized historically through laws and treaties that restrict or prohibit use or consumption. The Endangered Species Act (PL 93-205) is an example. These values are not generally related to the direct use of the resource. Existing economic theory is not well developed in this subject area; therefore, the Forest Service and Soil Conservation Service are cooperating in another study to improve our analysis capability through the VWRB Research Project, Rocky Mountain Forest and Range Experiment Station. This effort will develop a theoretical paradigm for existence values of wildlife and fish and carry out two case history studies based on that theory. We hope that, by 1987, a theoretically acceptable and tested model will be available.

Implications and Opportunities for Resource Management Programs

Through RPA and RCA, the Department of Agriculture is required to consider the implications that national assessments and appraisals have for agency programs on wildlife and fish populations and habitats, and to consider opportunities to change them such that the resource situation will improve. The national RPA Assessment and RCA Appraisal indicate how the Nation's natural resources could be managed—not how they necessarily will be managed. The Forest Service and the Soil Conservation Service have developed or are developing prescriptive analyses to address the mandate. The agencies are exploring the opportunity for using common data bases and analytic methods to answer different questions for different regional configurations of the land base.

A multiresource linear programming model is used to allocate land to management actions. Such a model tracks the resource production and costs associated with the prescribed management actions and selects the quantity of land to be managed on the basis of targets for resource production and objectives such as economic efficiency or least cost. The Forest Service currently uses a multiresource linear programming model (FORPLAN) in National Forest planning (Johnson et al. 1980), and the Soil Conservation Service also uses a linear programming model (CARD) for national planning (USDA Soil Conservation Service 1979). With these models, it is possible to address questions about physical resource production tradeoffs and alternative program goals that might be desired.

The Forest Service LRMP Research Project is currently developing a National Assessment Multiresource Model (NAMM). This linear programming model process will use information developed during the current National Forest planning process and similar information being developed for forest and range lands that are not in the National Forest system (Hof et al. in press). The models being developed for non-National Forest System lands will be regional and will provide a coarse level of resolution sufficient for national opportunity analyses. Data on wildlife and fish habitat and populations will be modeled so that their response to land management actions can be estimated on non-National Forest System lands. Production estimates of wildlife and fish standing crop will be incorporated along with those for other resources in NAMM. One result of this opportunity analysis will be hypotheses relating land management alternatives, resource production tradeoffs, and the joint cost of production.

The Soil Conservation Service's CARD model deals basically with resource availability (nonfederal land available for crop production)—the production capability, transfer, and transformation of such land and resource demand. The CARD model is regional and provides a level of resolution sufficient for national opportunity analysis. Data on wildlife and fish as described in this paper will be modeled to provide estimates of the wildlife and fish response to land management on nonfederal lands. Production estimates resulting from changes in land use, land cover, and vegetation structure will be interpreted from crop production alternatives developed by the CARD model. The result will be an assessment of the effects that hypothetical changes in agricultural technology, land and water use, and environmental protection and resource production will have on quantities and quality of wildlife and fish resources.

Regional Monitoring through National RPA Assessments and RCA Appraisals

Salwasser et al. (1983) described the mandates for monitoring wildlife and fish resources at the project or management unit level of planning for several state and federal agencies. This paper has discussed the regional analyses and data that the USDA Forest Service and Soil Conservation Service are testing for use in developing the wildlife and fish portion of the 1989 RPA Assessment and the RCA Appraisal.

Assessments and Appraisals are descriptive of the current and future resource situation on all forest and range lands in the case of the Forest Service, and all non-federal lands in the case of the Soil Conservation Service. The regular periodic description of the current resource situation, projection of wildlife and fish inventories and use, and a prescriptive analysis of alternative future opportunities for managing the nation's natural resources carried out by the USDA Forest Service and Soil Conservation Service are a significant national mechanism for monitoring wildlife and fish resources.

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Monitoring Wildlife Habitat and Validation of Wildlife-Habitat Relationships Models

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> Validation of ecosystem models is a challenging problem for the modeler and the difficulty of validation is a major deterrent to acceptance of the modeling approach by experimental ecologists.
>
> Mankin et al. (1977)

Many resource agencies are developing information systems and models for predicting and monitoring wildlife through habitat relationships. Wildlife-habitat relationships (WHR) models are taking many forms, but a near-universal premise of the models is that distribution and abundance of wildlife species may be predicted from habitat components. We address the validation of WHR models by discussing (1) aspects of WHR models that lend to testing, (2) theory and criteria of model validation, (3) designing and conducting WHR validation studies, and (4) case studies of WHR models for monitoring purposes.

WHR Modeling and Validation Theory

Modeling in ecology usually refers to simulation models, which represent natural systems diagrammatically as boxes and arrows (e.g., Figure 1), and mathematically as time-dependent (e.g., differential) equations. Many WHR models, however, are not time-dependent and assume causal relationships between habitat characteristics and the responses of species (e.g. Thomas 1979, Short and Burnham 1982, Patton 1978).

A model, being a formal representation of some system of interest, may be used to help us understand how the real system works through causal relationships, and/or to make predictions. WHR predictor variables may be those that are more easily measured or manipulated (e.g., successional stage of a forest stand) or those that indirectly represent the true causal variable (e.g., canopy depth as an index to roost microclimate). Whether the functional relationships and predictions of species' responses in WHR models are in some sense *valid* is a fundamental problem of WHR model-building and application.

Modeling generally proceeds through four phases: conceptual, diagrammatic, symbolic, and computer-based (Hall and Day 1977). In this light, mathematics and

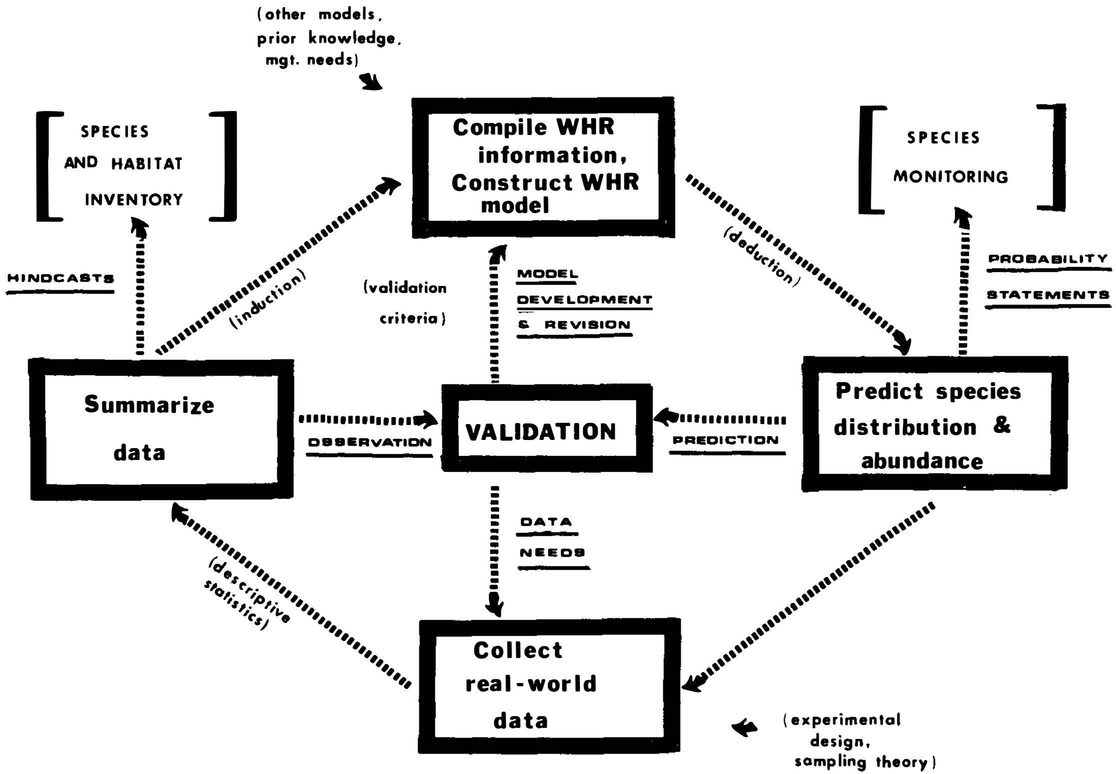

Figure 1. The central role of validation in the process of building and using wildlife-habitat relationships (WHR) models, showing stages in the modeling cycle (boxes); intermediate products (underscores); supporting information, theories, and techniques (parentheses); and applications (brackets). Monitoring and inventory may themselves become information summaries and prediction models, subject to further validation.

computer programs are simply more explicit representations of concepts and diagrams. What level(s) does validation address? The *rational* approach views theorization and model building as a hypothetico-deductive process (e.g., Romesburg 1981) in which model validation focuses on developing concepts that explain system behavior. The *empirical* approach focuses on the validity of model output; the conceptual level is shielded from direct validation (Jacoby and Kowalik 1980).

Validation is actually useful on all levels of model representation, from concept to computer. Validating a concept, for example, involves exploring how well it matches what we already know, as well as testing the validity of models and predictions that may be deduced from it. This essentially a *contextual* approach, by identifying the contexts in which a model is valid. WHR modeling draws from *a priori* professional judgments (e.g., Zuboy 1981) as well as empirical field studies to define relationships, parameters, and model structure. Model evaluation should be an integral part of model building, as validation involves generating alternative models, devising tests, and revising models (Farmer et al. 1982, Caswell 1976, Law and Kelton 1982, Gentil and Blake 1981). The final judgment, however, relies on predictions. This is where we will focus attention.

Validation, for our purposes, is defined as the determination of the usefulness and accuracy of model predictions and of model implementation in impact assessment, planning, and monitoring. The WHR modeling process may begin in any of the stages shown in Figure 1. Empirical observations of the distribution and abundance of species or habitat may be summarized and, along with ancillary models and prior knowledge, be compiled into an information base and generalized into a species-response model. The model may in turn be used to predict species' responses to habitat conditions and may spur further field studies. At the heart of the cycle, the validation process in some way compares model predictions to observations of species' responses (or to prior knowledge), determines the strong and weak points of the model according to specified criteria, and guides further empirical studies or model development and revision.

Why take the trouble and expense to validate WHR model predictions? Validation allows determination of confidence levels of model predictions and use for management decisions, testing of the adequacy of available habitat inventory data for predicting species' responses, refining of habitat inventory procedures to increase model reliability, and identification of fallacious model assumptions and faulty model constructions. As with the original formulation of a WHR model, validation hinges upon explicitly stated criteria.

Criteria and Procedures of Model Validation

Validation procedures are problem-specific according to model objectives (Gass 1977, Overton 1977, Van Horn 1969, Mankin et al. 1977). Criteria for validation (Table 1) may be chosen for specific purposes according to the type and complexity of predictions generated from WHR models, the level of model building and revision, and legal and management needs. An additional means of assessing model predictions may be the "Turing test" (Turing 1950; suggested by Van Horn 1969, McKenney 1967, Shannon 1975, Farmer et al. 1982), in which professionals try to distinguish between unlabelled summaries of model predictions and empirical observations. Explaining discrepancies helps identify weak points of the model.

Table 1. Criteria for model validaton.

Criterion	Explanation	References
Precision	Capability of a model to replicate particular system parameters.	Levins 1966, Walters 1971
Generality	Capability of a model to represent a broad range of similar systems.	Levins 1966, Walters 1971
Realism	Accounting for relevant variables and relations.	Levins 1966, Walters 1971
Precision	Number of significant figures in a prediction or simulation.	Hall and Day 1977
Accuracy	How well a simulation reflects reality.	Hall and Day 1977
Robustness	Conclusions that are not particularly sensitive to model structure.	Hall and Day 1977
Validity	A model's capability of producing all empirically correct predictions.	Mankin et al. 1977, Gass 1977
Usefulness	If at least some model predictions are empirically correct.	Mankin et al. 1977, Gass 1977, Schrank and Holt 1967
Reliability	The fraction of model predictions that are empirically correct.	Mankin et al. 1977, Leggett and Williams 1981
Adequacy	The fraction of pertinent empirical observations that can be simulated.	Mankin et al. 1977, (see also Overton 1977)
Resolution	The number of parameters of a system which the model attempts to mimic.	Bledsoe and Jamieson 1969
Wholeness	The number of biological processes and interactions reflected in the model.	Holling 1966
Heurism	The degree to which the model usefully furthers empirical and theoretical investigation.	This paper
Adaptability	Possibilities for future development and application.	This paper
Availability	Existence of other, simpler, validated models that perform the same function.	Schrank and Holt 1967
Appeal	Matching our intuition and stimulating thought, and practicability.	This paper; see also Overton 1977
Breadth	Proportional to the number of (habitat) components addressed.	Farmer et al. 1982
Depth	Proportional to the number and kinds of variables chosen to describe each (habitat) component.	Farmer et al. 1982
Face validity	Model credibility.	Gass 1977
Sensitivity	Model variables and parameters matching real-world counterparts; their variation causing outputs that match historical data. Also, dependence of model output on specific variations of variables.	Gass 1977, Van Horn 1969, and others
Hypothesis validity	The realism with which subsystem models interact.	Gass 1977
Technical and operational validity	Identification and importance of all divergence in model assumptions from perceived reality, as well as the identification and importance of the validity of the data.	Schellenberger 1974
Dynamic validity	Analysis of provisions for application to be modified in light of new circumstances.	Schellenberger 1974

Tests of assumptions and the higher-level theories used to derive models is a fuzzier, albeit vital, step (Farmer et al. 1982, Law and Kelton 1982, Shannon 1975). The credible professional is one who is able to explain the assumptions, reasoning, tools, and evidence that were relied upon to form conclusions (Simon 1977). "Soft-testing" (i.e., without standard statistical procedures) assumptions and theories first involves the deceptively difficult task of articulating them in clear and precise statements, and then assessing their limitations and pertinence to the modeling objectives.

Invalidation

Models, as hypotheses about nature, cannot be proven correct, but merely corroborated by experiences and tentatively accepted until proven false (Popper 1959, Farmer et al. 1982, Naylor and Finger 1967, Caswell 1976). This approach holds true with formal, statistical hypothesis testing at the level of matching specific model predictions with specific observations. However, the decision to call a model valid or not valid goes beyond prediction-observation matching and hypothesis-testing. Any model will appear false when used in the wrong set of circumstances. Defining the ecological context in which a WHR model predicts well, according to criteria as discussed above, is the key. Such contexts, for example, may include habitats, seasons, and species that specify when a model may be used with confidence.

Falsification is better seen as a statistical problem of determining the accuracy of specific model predictions rather than the overall usefulness or validity of the model *in toto*. Classical statisticians speak of errors of rejecting true predictions and accepting false ones. Bayesian statisticians speak of probabilities of hypotheses being correct, given some initial knowledge or set of conditions. Bayesian approaches to modeling and validation have been suggested by Rubenstein (1975), Mankin et al. (1977), and others, and used by Williams et al. (1977) and Mangel and Clark (1982). Bayesian assessments of predictions may serve WHR modeling by forcing the articulation of prior assumptions and knowledge.

Designing Field Studies to Validate WHR Models

General Considerations

Different levels of complexity of predictions (model outputs) require vastly different study designs to assure collecting appropriate and sufficient data. For example, different WHR models may predict presence of all vertebrate species in each of several successional stages of a forest type, the suitability of each stage for breeding, or reproductive success of a particular species, such as the spotted owl *(Strix occidentalis)*. The first example requires collecting only presence-absence information on each species in each habitat, the second requires data on relative abundance or density, and the third requires demographic information. Seber (1973), Caughley (1977), papers in Ralph and Scott (1981), and White et al. (1982) discuss specific sampling methods and analytic procedures.

Researchers must also consider validation criteria and levels of acceptability. Criteria may influence the design of field studies and thus should be considered first. If a model predicts the presence of a species, the species may actually be present *(a)* or absent *(b)*; if the model predicts absence, the species likewise may be present *(c)* or absent *(d)*. An important criterion is model reliability, which is calculated as the fraction of model predictions that are correct within acceptable limits of probablity. Over a number of prediction-observation assessments, reliability may be calculated as $(a + d) / (a + b + c + d)$, and this percentage may be compared with desired levels or levels generated by other models. For example, one might want to predict with 90 percent probability the presence or absence of 75 percent of all species found in each of three habitat types. More sophisticated predictions could include being 90 percent certain of detecting 75 percent of true correlations (at, say, the 90 percent significance level) between a habitat suitability scale and the relative abundance of a set of species.

Establishing the Sampling Frame

One goal of the sample design for validation is to assess reliability by minimizing the proportion of sampling errors. Two types of errors may result from field samples, similar to errors of model prediction. The first involves species that are sampled as present in inappropriate habitat. This type of error is difficult to eliminate, but can be controlled by limiting sampling to periods when a species is most closely tied to its suitable habitat (e.g., breeding period for birds rather than post-fledging period), by setting some minimum criteria for accepting a presence record (e.g., occurs on at least 10 percent of replicate plots or censuses), and by using ancillary information to supplement census or trapping data (finding nests or observing foraging in the habitat type).

The second type of error, failing to find a species in what is actually suitable habitat, can be controlled by sampling effort. As effort is limited by cost and time, the possibility always exists that a species could have been detected had more samples been taken. Researchers must allow, therefore, that a certain fraction of model predictions will fail due to sampling error. The reliability criteria chosen must incorporate a reasoned estimate of the likely fraction of species for which sampling methods or effort are inadequate and either eliminate those species from consideration or account for them in the reliability percentage value.

Determining sample size. Sample size is probably the most important design feature. An appropriate sample size will depend on the complexity of model predictions (presence or absence versus relative abunbance, etc.) and the number, behavior, and abundance of the wildlife species involved.

Models which predict only the presence of species will require the most modest sample sizes. To detect presence, the number of study plots can be determined that will have a specified probability of including some minimum number of detections of the less common species of interest. To estimate density of the same species, sample sizes must be on the order of 30 or more times as large so that counts are adequate (see, for example, Burnham et al. 1980). To test predictions of differences in density for a species among two habitat types, sample sizes must be even larger. For example, Dawson and Verner (in prep.) calculate that detecting a 50 percent difference in density between two areas at the 5 percent significance level would require sample sizes of about 50 and 50,000 censuses of species averaging 10 and 0.01 detections per sample, respectively.

The expected number of detections per sample is influenced by species home range size and observability. Observability is the probability of detecting a species given that it is within the detection range of an observer. Some mammals, for example, are trap-happy or trap-shy, and some birds are silent and motionless, but others give continual detection cues. That behavioral traits should influence sampling effort required to detect each species is illustrated from data gathered by one of us (MGR) on bird populations in late successional Douglas-fir *(Pseudotsuga menzeisii)* forests of northwestern California (Table 2). In this study, 1,632 ten-minute variable circular-plot censuses (Reynolds et al. 1980) were conducted during spring 1982. Detection rates declined with increasing home range and with decreasing observability. Sample size, then, should be determined by those species of interest with the lowest detection rates.

Figure 2 illustrates that doubling sampling effort (number of replicate censuses) resulted in about a 10 percent increase in the number of species detected. In this case, 25 percent of all 1,632 censuses would have been sufficient to detect 90 percent of the total species ultimately recorded over all censuses in spring and 70 percent of the species in winter.

Table 2. Detection rates estimated from 1,632 ten-minute breeding bird censuses in relation to home range size and observability of bird species, in Douglas-fir forests, northwestern California, 1982.

Home range size and species	Observability[a]	Number counted	Detection rate (Average no. per census)
Large home range > 100 acres (40 ha)			
Pileated woodpecker (PIWO) *(Dryocopus pileatus)*	H	115	0.07
Common raven (CORA) *(Corvus corax)*	M	88	0.05
Accipiter spp. (ACCI)	L	10	0.01
Moderate home range ~ 20 acres (8 ha)			
Steller's jay (STJA) *(Cyanocitta stelleri)*	H	878	0.54
Hairy woodpecker (HAWO) *(Picoides villosus)*	M	164	0.10
Red-breasted sapsucker (RBSA) *(Sphyrapicus ruber)*	L	119	0.07
Small home range < 20 acres (8 ha)			
Red-breasted nuthatch (RBNU) *(Sitta canadensis)*	H	816	0.50
Brown creeper (BRCR) *(Certhia americana)*	M	585	0.36
Winter wren (WIWR) *(Troglodytes troglodytes)*	L	240	0.15

[a]H = high, M = moderate, L = low. Based on combination of frequency of cue production and loudness (effective detection distance).

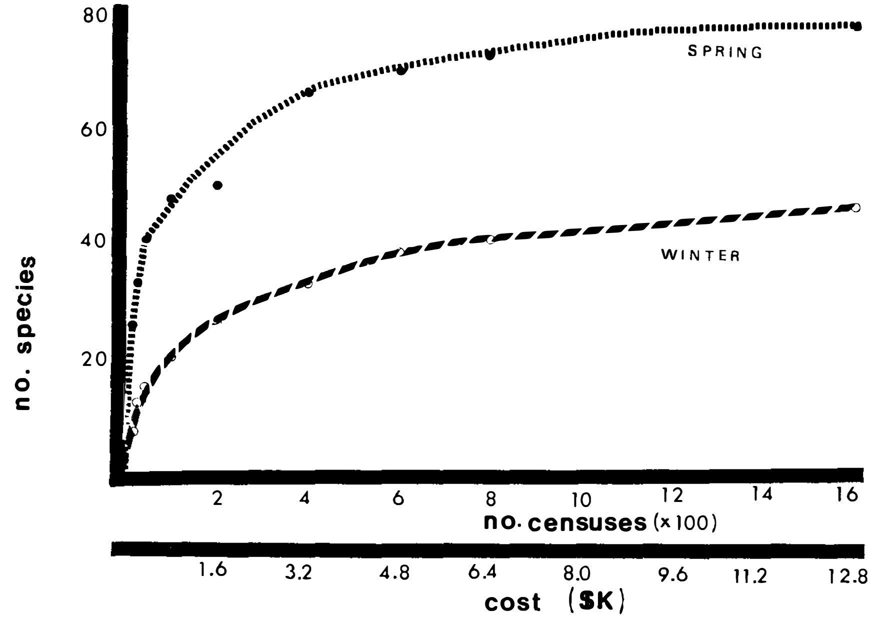

Figure 2. Number of bird species detected in relation to sampling effort and cost, spring and winter 1982. Data based on 1,632, 10-minute variable circular-plot censuses in each season conducted in medium-to old-growth Douglas-fir forests, northwestern California.

Replication of samples. To validate models over a number of different habitats, field samples must be taken in each, unless a strong argument can be made to extend the results of validation in one habitat type to another. Again, the number and pattern of samples within each type will depend on the number and complexity of the model predictions. Study plots should be as representative of each habitat type as possible, ideally, by randomly choosing plots from the entire area of interest. Random sampling of plots is rarely possible because of inaccessibility, logistics, and land management conflicts. Alternatively, plots can be selected to incorporate the full range of between-plot differences (e.g., presence of streams, topographic features, etc.) or, preferably, to represent the modal condition within the range of observed variation in a habitat type.

Study duration. Samples drawn from any one season or year can be misleading if a given population is at an extreme. Validation studies should span at least three years to detect fluctuations in numbers and distributions. For example, we examined the cumulative occurrence of nine bird species on each of 136 Douglas-fir study plots over four sampling periods covering two years (Figure 3). Percent occurrence of the more abundant species was determined in the first two sampling periods, whereas occurrence of rare species increased at a nearly constant rate with each additional sampling period.

A choice of replicating either sample area or time must consider both the distribution of costs between initial setup of plots and repeated sampling, and an

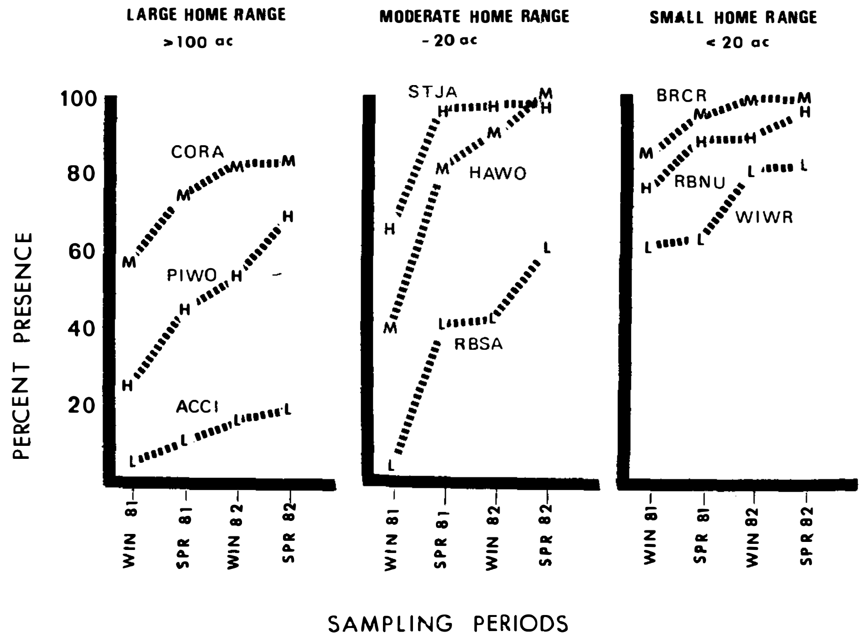

Figure 3. Cumulative occurrence (percentage of study plots on which a species was found) of birds in relation to number of sampling periods, home range size, and species observability (see Table 2). Observability: H = high, M = moderate, L = low. Data based on 1,632 10-minute variable circular-plot censuses in each sampling period conducted in medium- to old-growth Douglas-fir forests, northwestern California. Bird species codes are in Table 2.

assessment of true temporal variation in the distribution of the species in question, especially concerning rarer species. The risk of biasing results from unusual circumstances during one sample period (e.g., concentrated food supply, extreme temperatures) will almost always warrant extending a study over as long a time period as possible.

Cost

Study costs are a function of the number of model predictions to be tested, the complexity of the data sought, the characteristics of the taxa to be sampled, and the peculiarities of the habitat of interest. Returning to our example, detecting the presence of all but five bird species recorded from 1,632 censuses cost roughly $6,400 (averaging $89 per species, 1981 dollars) during spring (Figure 2). Detecting presence of the remaining five species doubled the study cost to $12,800, at an average of $1,280 per new species. If density estimates of the same species were required, costs would have exceeded $384,000 for all species; half this cost would have been spent on the five rarest species (averaging $38,400 each). Costs increase when model predictions include comparisions of density among habitat types. For example, in our studies, 4 out of the 77 species observed during spring averaged 1.0 or greater detections per census, 26 species averaged 0.1 or greater, and 50 species averaged 0.01 or greater. Based on sample sizes (number of censuses) estimated by Dawson and Verner (in prep.), detecting a 50 percent difference in density between two habitat types for the preceeding sets of species would cost \$8,000, \$80,000, and \$800,000, respectively. Detecting a more subtle difference of 25 percent for the same species would require ten times the sampling effort and cost!

Costs vary among different taxa and sampling methods. Table 3 gives annual costs associated with an ongoing study designed to sample as many terrestrial vertebrate species as possible (excluding bats) in Douglas-fir forests. Bird censusing is the cheapest sampling method. More specialized activities, such as intensive salamander searches and owl surveys, are more expensive. The most expensive method, two orders of magnitude greater than bird censusing, was live-trapping rodents. Pitfall traps determined presence of most of the live trapped species at a fraction of the cost, but live-trapping gave density estimates, and some species (e.g., *Neotoma fuscipes*) were not captured using pitfalls. A need for relative abundance or density data for particular taxa could, therefore, justify the use of more expensive sampling methods.

Table 3. Costs (1981 dollars) of sampling methods used to survey forest vertebrates in Douglas-fir forests (see Raphael and Barrett 1981 for full description of methods).

Sampling method	Taxa sampled[a]	No. plots sampled	No. species detected	Total cost[b] per year (\$K)	Average cost per species per plot
Variable-circular plot census (1 per plot, 2 seasons)	Diurnal birds, squirrels (P,R,D)	136	97	28.9	\$1.09
Pitfall traps (10 per plot, 4 seasons)	Small mammals, reptiles, amphibians (P,R)	134	22	31.6	2.68
Live traps (100 per plot, 1 season)	Small mammals (P,R,D)	18	8	13.9	96.53
Track stations (1 per plot, 1 season)	Larger mammals (P)	135	15	15.7	7.75
Litter search (3 per plot, 1 season)	Salamanders (P,R)	30	9	4.1	15.19
Owl survey (1 per plot, 1 season)	Nocturnal owls (P)	86	5	6.3	14.65

[a]P = presence detection, R = relative abundance estimates, D = density estimates.
[b]Includes initial set-up divided over three years.

Case Studies

Case studies on the flat-tailed horned lizard *(Phrynosoma mcallii)* and the desert tortoise *(Gopherus agassizii)* illustrate the development of WHR models from field surveys. Both species are under ''status review'' by the Fish and Wildlife Service for potential listing as threatened or endangered. The U.S. Department of Interior, Bureau of Land Management (BLM), has studied the flat-tailed horned lizard since 1978 and the desert tortoise since 1974, and manages much of their habitat.

Flat-tailed Horned Lizard

The flat-tailed horned lizard is a rare species of the Sonoran Desert of southeastern California, extreme southwestern Arizona, and adjoining parts of Sonora and Baja California Norte, Mexico. Habitat is in low, hot desert. The vegetation is typically a creosote bush-burrobush *(Larrea tridentata, Ambrosia dumosa)* scrub with a variety of soil types ranging from some desert pavements interspersed with blow sand to low dunes (Turner et al. 1978, and Turner and Medica 1982).

The goal of the studies was to determine distribution and relative abundance and to correlate these parameters with habitat characteristics, to determine status of populations, and, where possible, to identify key populations and habitats in California. The BLM hoped that a model for predicting the presence of relatively high density populations could be developed through an analysis of lizard abundance and habitat attributes.

The study involved three phases (Turner and Medica 1982). During the first year, nine 10-acre (4.1-ha) study plots were established through the geographic range in California in areas known or expected to support horned lizard populations (Turner et al. 1979). The objective was to relate lizard density to numbers and kinds of perennial and annual plants, cover of shrubs and trees, soil types, and counts of active nests of 13 species of ants. This effort was not successful because only four of the nine plots had horned lizards and only one of the four had ''normal'' horned lizard densities. However, a direct relationship between abundance of lizards and abundance of lizard scat was established.

In the second year, hour-long walks were made in 458 1 square-mile (2.59-km^2) lots or sections (square miles) over a large portion of the geographic range in California (Turner and Medica 1982). Field workers recorded data on horned lizards, horned lizard scats, numbers of other lizard species, and numbers of black and red harvester ants (the principal food of the lizard). Indices of abundance were developed using horned lizards and their sign, and five "favorable" areas were identified. The investigators also found that abundance indices were dependent on effort; i.e., the higher indices were associated with high numbers of sections evaluated within a township (36 square-miles, 93 km^2). If only a few sections were examined per township, the results were questionable.

In the third year, five pairs of study plots were established with one member of each pair in ''good'' habitat and the other in ''poor'' habitat (Turner and Medica 1982). Good and poor horned lizard habitats were based on assessments of all data from the second-year plots. From each paired plot, data were gathered on relative abundance of *P. mcallii,* abundance and diversity of perennial plants, and relative abundance of harvester ants.

A stepwise multiple-regression analysis of the third year's data produced a regression model which predicted horned lizard abundance (relative numbers), L, as:

$$L = 75.0P + 8.6\,\Delta_1 - 0.4A - 7.9$$

where P = aggregate perennial plant density, Δ_1 = perennial plant diversity, and A = the harvester ant abundance index (Turner and Medica 1982). Relative abundance of lizards was significantly and positively correlated with aggregate perennial plant density ($r = 0.93$, $n = 10$ plots). The regression model explained about 91 percent of the observed variation in horned lizard abundance.

This effort cost the BLM $41,000 (the Department of Energy also made a significant and unspecified contribution) and resulted in identification of five areas favorable for horned lizard populations. However, future use of the model may be limited by the generally low sampling intensity (number of hour-long walks) that was done in each section, the heterogeneous habitat and patchy distribution of the species within the identified favorable areas, and ongoing deterioration of the habitat by human uses.

Desert Tortoise

The desert tortoise is a reptile of the Mojave and Sonoran Deserts of the southwestern United States and Mexico. It is generally found in the more productive creosote scrub and tree yucca (*Yucca* sp.) communities at elevations below 3,500 feet (1,066 m).

Studies on distribution, abundance, and attributes of populations, as well as impacts of various land uses on this species have been supported by BLM for 10 years (Berry 1983). The goal was to identify high density populations and to determine whether populations are stable, declining, or increasing.

Distribution and relative abundance were assessed by using 1.5-mile (2.4-km) strip-transects. Population attributes, including density, were determined with 30- or 60-day censuses of populations at 27 study plots 1 square mile (2.59 km^2) or larger. Over 1,500 strip-transects were made throughout the deserts, with an average of two per township. Data on live tortoises, shell-skeletal remains, scats, burrows, and other tortoise sign were recorded. Indices of abundances (tortoise sign counts) were calculated from each transect and plotted on maps (scale 1:250,000). Contour lines were drawn around areas with similar abundance index values.

Multiple transects were made on each of several study plots to quantify the relationship between tortoise sign counts and density estimates from censuses of live tortoises (Berry and Nicholson 1983). A linear regression of abundance index values on tortoise densities ($r = 0.83$, $n = 43$) allowed density estimates to be assigned to abundance indices; e.g., 1 to 3 signs were equivalent to 0 to 8 tortoises/0.4 square mile (1 km^2), 4 to 9 signs were equivalent to 8 to 19 tortoises/0.4 square mile (1 km^2), and 10 to 15 signs were equivalent to 39 to 97 tortoises/0.4 square mile (1 km^2).

A map of estimated tortoise densities was then prepared for California (Berry and Nicholson 1983). Validity of the map was tested first by establishing five new permanent study plots in areas with the preassigned estimates of density. Each plot was censused for 60 days. Tortoise densities were calculated by using the stratified Lincoln Index. Densities calculated from the five plots fell within the range shown on the prediction map. The tortoise density map has been further validated through comparisons with about 500 additional strip-transects.

Costs of the strip-transects, permanent study plots, and data analysis were about $100,000, although the map and linear regression models were only a small part of the overall analysis.

Federal and state agencies are using the tortoise density map and strip-transect data to determine whether tortoises are present in areas scheduled for land-use actions, and whether tortoise density is high enough to deserve special attention in an Environmental Analysis or Environmental Impact Statement.

Acknowledgements

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Monitoring Large Animal Populations: The Colorado Experience

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Introduction

No other group of big game animals on the North American Continent has received more investigative attention than members of the family Cervidae. Much of this effort has been directed towards enumeration or census. Despite the enormous amounts of resources that have been expended to develop census systems and to apply them, Connolly (1981b:226) remarked:

> No reliable estimate of mule or black-tailed deer numbers exists for any entire state or province. The only available estimates are speculative and often they are no more than guesses by the best-qualified persons.

Why is it that we have "no reliable estimates" of deer, or for that matter, of any other big game species inhabiting the West? In the western United States mule deer *(Odocoileus hemionus hemionus)* and black-tailed deer *(Odocoileus hemionus columbianus),* along with wapiti *(Cervus elaphus nelsoni),* are the "bread and butter" species which generate revenue (primarily through sales of hunting licenses) that funds much of the wildlife management activity of those states. So the answer to the question is not that deer, elk, and other big game animals are unimportant. We think the answer to the question is conditioned primarily by three interactive circumstances: we have few reliable methods to estimate population size; reliable methods are complicated, costly, or both; and states have not been confronted with a compelling need to quantify.

We do not pretend to have definitive answers to the challenge of censusing big game, but we do think that Colorado's experience in facing that challenge may be useful to other wildlife managers. In this paper we will:

1. briefly review the historical evolution of Colorado's big game monitoring systems;
2. highlight circumstances that led Colorado to begin implementation of a statewide deer monitoring system and to initiate research on potential inventory systems for other big game species;
3. review Colorado's deer monitoring system in terms of accuracy, precision, resolution, and frequency;
4. discuss possibilities for improving the deer monitoring system;
5. review ongoing research on candidate monitoring systems for elk and pronghorn *(Antilocapra americana).*

History of Colorado's Big Game Census

Big game census in Colorado passed through four major periods, which we think typify similar developments in other western states.

Era of Total Enumeration

The period from 1935–1945 could be called the era of total enumeration. Most of the census activities focused on mule deer. Biologists attempted to count total numbers of deer comprising the most important "herds" in the state. Crews of observers walked each drainage within winter range complexes and counted every deer they encountered. The sum of all counts over every drainage of a winter range was taken as the minimum population size of that herd (McCutchen 1938, Rasmussen and Doman 1943).

These activities were labor-intensive and time-consuming. Emphasis began to shift away from determinations of population size towards evaluations of deteriorating habitat condition (Hunter 1945). Deer populations in the West had rebounded remarkably from scarcity in the decades of the 1920s and the 1930s to abundance in the 1940s. It was generally agreed that census was not the most pressing problem of the 1940s. Deer were quickly exceeding the carrying capacities of their winter ranges, whatever their numbers. The pressing problem was how to control populations before they seriously damaged the support capacity of their native rangelands (Hunter 1945).

A curious historical footnote of this era was that methods had been developed and implemented that employed sampling theory to *estimate* population size. Bennett et al. (1940) described a method to estimate deer population size from sample counts of fecal pellets. They suggested that this system presented a simple, practicable, and inexpensive method for censusing deer. Aerial survey, however, provided an even simpler, more practicable, and less expensive census method. Questions of comparative accuracy or precision were not raised.

Era of Trend Indices

We characterize the period from 1945–1970 in Colorado as the era of trend indices. Population enumeration and estimates of population size yielded to trend counts. Trend count efficacy was based on the assumption that intensive surveys of small areas could be used to track relative changes in deer numbers over large areas. Trend areas were assumed to "represent" changes occurring over the larger areas of interest (Gill 1976). The central assumption of a trend index is that it is a constant fraction of the total population or that the relationship of the total population to the index is reliably predictive (Eberhardt 1978). This assumption was rarely questioned and even more rarely tested. The attractiveness of trend counts resided in their simplicity and dispatch.

Aerial survey methods were introduced into Colorado's big game census programs in 1938 (Riordan 1948). Initially aircraft were used to attempt total counts of individuals herds, but by 1945 aerial counts were confined to trend plots, which were assumed to "give a true picture of the average condition" (Hunter 1945:234). Some wildlife biologists questioned the accuracy of aerial counts, recognizing that the price of simplicity, practicality, and economy was reduced accuracy. Gilbert and Grieb (1957) developed correction factors to adjust aerial counts for observability biases, but their results were largely ignored.

The era of trend indices brought several technological advances, including the advent of helicopters (Buechner 1950, Owens 1959) and the introduction of remote sensing technology (Gilbert 1959), but no major conceptual advances occurred. No one seriously challenged the central assumptions of trend counting—i.e., their representativeness and their relationship to total populations (Besadny 1979).

By the late 1960s, it was becoming obvious even to die-hard champions of trend indices that they were not very useful biological tools (Denney 1976). Trend indices were retained primarily for their public relations values and because there were no simple, practical, and economic alternatives.

Era of Simulation Modeling

In the late 1960s and early 1970s, Colorado wildlife managers came to realize that trend indices of deer and elk populations "had little direct input in the formulation of season regulations" (Denney 1976:89). Concurrent with the demise of trend counting in Colorado, simulation models of big game populations were being developed that could provide estimates of total population size and still retain simplicity, practicality, and economy (Pojar 1977a). The period of 1970–1975 we call the era of simulation modeling.

During this era, Colorado redesigned its big game management system. Past systems had been based upon a "herd unit" or "game management unit" concept. Geographic areas were mapped to encompass the seasonal ranges of all deer, elk, and pronghorn populations in the state. Data were collected to relate to these "herds."

Beginning in 1970, combinations of game management units were grouped into larger units called data analysis units (DAU's) Distribution studies of big game animals revealed that the old game management units did not accurately define population boundaries (Bartmann and Steinert 1981, Carpenter et al. 1979). Also, combinations of game management units into data analysis units increased the precision of harvest estimates—the population statistic routinely collected for all big game populations in Colorado.

Gross (1970) developed a simulation model for big game populations which essentially was a computerized life table (Pojar 1981). From the period 1970–1975 efforts were made to estimate with simulations the size of all important Colorado deer and elk populations. Probably the most significant outcome of these activities was to reinforce the need for accurate and precise input data, particularly estimates of population size and population composition (Pojar 1979). Colorado came to realize that even though population simulation was simple, practical, and economical, it was no panacea to the big game monitoring problem.

Era of Sample-based Estimates of Population Size

The period from 1975 to the present is characterized as the era of sample-based estimates of population size. This era really was a full-circle return to the era of total enumeration in one sense. We have no short-cut methodology to population monitoring. Population size had to be measured to reliably track changes in populations over time, but neither resources nor technology were available to count every animal, everywhere, every year.

During the late 1960s, wildlife researchers made significant progress in big game census by combining aerial survey methodology and sampling theory (Siniff and Skoog 1964, Evans et al. 1966, Mangold 1966, Gill 1969, Jolly 1969). A combination of legal and biological circumstances compelled Colorado to begin implementing these census advancements on a statewide basis.

Circumstances Leading to a Statewide Deer Monitoring System

Legal Circumstances

Passage of the National Environmental Policy Act (NEPA) in 1969 drastically changed the way of doing business for all state wildlife conservation agencies. After a decade of judicial and legislative definition, the legacy of NEPA is now becoming clear. Impacts of human activities upon lands within the public domain must be evaluated objectively and quantitatively. This mandate has been reiterated and codified further in several additional legislative acts (Salwasser et al. 1983).

The Marine Mammal Protection Act of 1972 established precedents for population monitoring at the level of the Federal government. This act provided that marine mammals within United States territorial waters would be harvested "to obtain an optimum sustainable population keeping in mind the carrying capacity of the environment." The act required: (1) estimates of population size, recruitment, and mortality rates, and (2) estimates of carrying capacity of marine environments in terms of animals numbers. The Marine Mammal Protection Act is relevant to state wildlife conservation agencies because it resulted from lobbying activities of wildlife citizen advocates to prevent perceived over-exploitation of marine mammal populations. This federal law preempted states' rights to manage marine mammals, and it is regarded by wildlife advocacy groups as a model law for all exploited wildlife populations.

The Forest and Rangelands Renewable Resources Planning Act of 1974, as amended by the National Forest Management Act of 1976, instructs the Secretary of Agriculture through the U.S. Forest Service to: "prepare a renewable assessment which shall be updated every 10 years and shall include . . . an inventory based on information developed by the Forest Service and other federal agencies of present and potential resources."

In addition, the Federal Land Policy and Management Act of 1976 assigned to the Secretary of Interior basically the same responsibilities for public lands administered by the Department of Interior. During the 1970s, a plethora of legislation was enacted to cope with surface mining and mined-land reclamation activities. These laws basically required that measurements be made to monitor wildlife resource status before, during, and after land disturbances.

Collectively, these legal precedents establish federal responsibility and authority for wildlife monitoring activities on federal lands. Federal agencies are encouraged to cooperate with state wildlife agencies, but are not required to do so. The implications are clear. State wildlife agencies must become more responsive to the monitoring initiatives mandated by federal law or Federal agencies will assume that responsibility.

Biological Circumstances

The recent, much touted, mule deer decline in the West (Workman and Low 1976) and the legal challenge to the Pittmann-Robertson (P-R) program by the Committee for Humane Legislation (Starnes 1979) both emphasized the need for more responsible stewardship of big game resources. Concern for an apparent decline of mule deer populations over the entire western United States prompted a symposium in Utah in April, 1976 to determine causes for the decline. Gill (1976) and Wolfe (1976) argued that the information base was so meager that even the fact of a mule deer decline was speculation, an observation that Connolly (1981a,b) reiterated five years later.

The lawsuit by the Committee for Humane Legislation was based partly upon a claim that states were derelict in their responsibilities for wildlife. The suit contended that state wildlife agencies that received P-R funds for wildlife restoration projects were using those funds primarily to enhance game populations to the possible detriment of nongame populations. The suit also contended that the states had too little data regarding responses of game and nongame populations to permit objective evaluations of P-R funded habitat alterations, and that the state wildlife agencies should be enjoined from additional expenditures of P-R funds until those data were available.

The western states survived the apparent mule deer decline, and the lawsuit of the Committee for Humane Legislation was decided in favor of the defendants. However, the basic question remained unresolved. Did the states have adequate monitoring systems to meet their legal and professional obligations to the public's wildlife resources? Colorado responded to these challenges by developing and testing candidate monitoring systems for mule deer and implementing promising systems as rapidly as feasible. Colorado also initiated research to develop improved systems for monitoring elk and pronghorn populations.

Colorado's Deer Monitoring System

Testing and Implementation of Candidate Census Systems

A review of research on methods to estimate total populations of deer over large tracts of land characteristic of Colorado's deer ranges revealed two methods that were conceptually, practically, and economically feasible for statewide implementation. These were pellet group counting and sample-based aerial counts from helicopters (Harris 1959, Gill 1969, Anderson et al. 1972, Bartmann 1974). It was obvious that no single system would apply over all areas of the state. Topography, weather, and vegetation composition were primary factors dictating which system could be used at different locales.

Aerial survey from helicopters was the method of choice wherever possible, because it required smaller blocks of time, was more accurate than counts from fixed-wing aircraft, and provided direct estimates of population size. Aerial surveys could not be used, however, in areas where combinations of topography, turbulent winds, and mottled snow background precluded accurate and consistent counts. In Colorado, these conditions are characteristic of the entire eastern slope of the Continental Divide, but most of the western half of the state is suitable for helicopter surveys.

Beginning in 1975, the Research Section of the Colorado Division of Wildlife selected one Game Management Unit within each of Colorado's four wildlife management regions to test candidate deer monitoring systems. Wildlife management personnel selected Game Management Units, and the research staff selected the candidate census system most appropriate to each Game Management Unit.

In the two eastern regions of Colorado, permanent plots were installed to estimate pellet group densities. Deer densities were calculated from pellet group densities, based upon assumed defecation rates (Harris 1959, Anderson et al. 1972, Neff 1968, Ryel 1971) and known periods of fecal accumulation (Anderson 1977, Pojar 1977b).

A helicopter quadrat system was developed for the southwest region (Kufeld et al. 1980). In the northwest region a helicopter quadrat system was already being tested (Bartmann 1974) so an estimating system using pellet groups was installed to compare results of the two systems to estimate deer population size (Freddy and Bowden 1983b).

Results of these tests are in the process of publication, but briefly, logistically feasible pellet group counting systems in the two eastern regions yielded estimates of deer population size that were not unrealistically high or low. In the northwest region, populations were estimated from pellet counts on permanently marked plots and from temporary plots that were not cleared of pellet accumulations. Freddy and Bowden (1983a) concluded that temporary plots were more practical because they were easier to implement, were less costly, and yielded comparable estimates of population size. Comparisons of deer population estimates calculated from pellet group densities versus helicopter quadrat estimates yielded mixed results. In 1976, the two census systems resulted in estimates that were not statistically different. In 1977, a lack of snow precluded the aerial survey, but the estimate derived from pellet-group densities was unreasonably high when compared to the 1976 estimates and simulation estimates (Freddy and Bowden 1983b).

Helicopter quadrat-census estimates of deer in the southwest region test area yielded results that were consistent with simulation estimates based upon population composition and harvests (Kufeld et al. 1980)

Currently, helicopter quadrat censusing of deer is being expanded to other areas within the southwest, southeast, and northwest regions of Colorado. No census systems have been implemented in the northeast region. Censuses based upon pellet densities have not been implemented by wildlife managers in any game management unit in the state despite favorable testing by researchers.

Questions of Accuracy, Precision, Frequency and Resolution

All of the census systems currently being implemented in Colorado are endowed with traditional problems regarding accuracy, precision, frequency, and resolution. We characterize accurate estimation procedures as those which have small biases and good precision (Figure 1). Accuracy, however, is seldom attainable in wildlife population censuses. We can evaluate accuracy only by estimating bias and precision from samples (White et al. 1982). Biases are barriers to accuracy because they preclude congruence of estimated values and their expected values no matter what sample sizes are obtained. Biases have been classified by White et al. (1982) as small-sample biases and model biases. Model biases are the more serious of the two because important assumptions implicit to the sampling system are not correct.

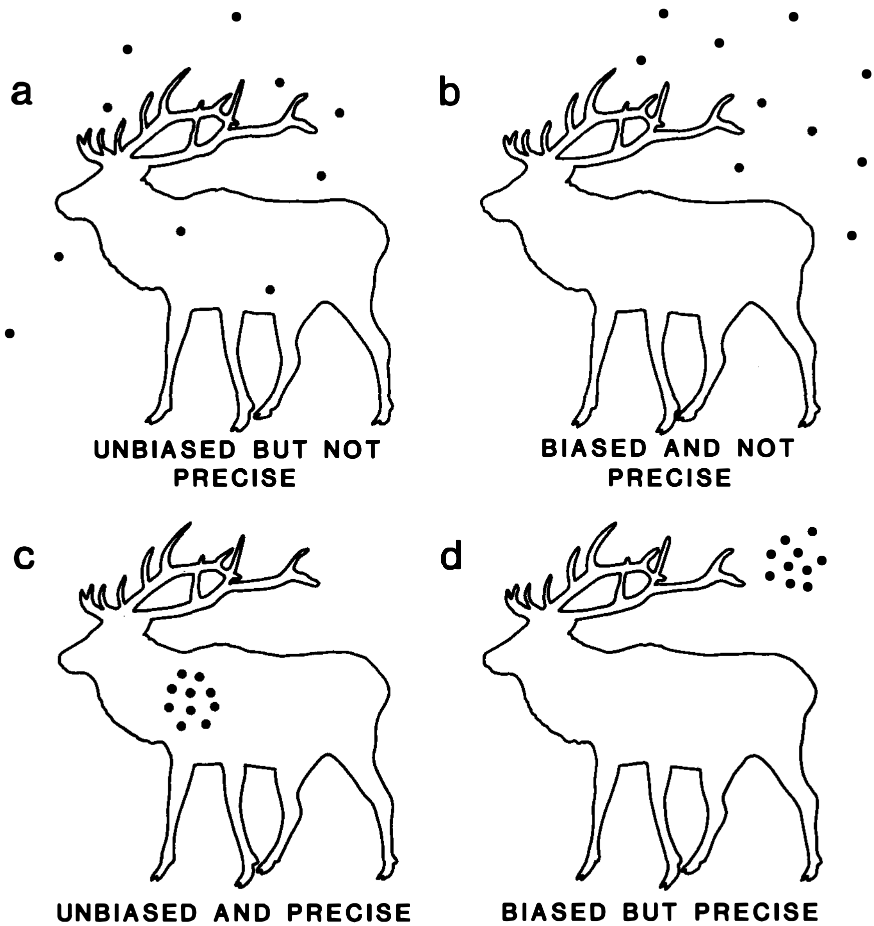

Figure 1. Concepts of bias and precision.

Precision "relates to the repeatability of the result" (White et al. 1982:19) (Figure 1). Precision can be quantified by the sampling variance and be improved by increasing sample size, by employing alternative sampling strategies, or both.

Resolution refers to the degree or extent to which we want samples to apply. Will data apply to deer on a single acre within a drainage, within a herd unit, or within a state? These are questions of resolution.

Frequency refers to how often the census is repeated. In populations with rapid turnover rates, it is necessary to census more frequently than in those with longer turnover rates.

Our mule deer censuses in Colorado are used as though they were free of serious methodological biases because they yield empirically reasonable results. Careful investigations are needed of the magnitude of biases in detectability and what factors exhibit the most dramatic effects on deer detectability during aerial surveys.

Research progress in this area of census development exists (Caughley 1974, 1977, Caughley et al. 1976, Caughley and Grigg 1981).

Several Colorado researchers have begun to examine methodological biases inherent in censuses based upon pellet densities. Early work by Bowden et al. (1969) examined alternative theoretical frequency distributions to improve estimation precision. They also described techniques to minimize undercounting the number of pellet groups per sample unit. Strong and Freddy (1979) estimated the mean number of pellets per individual defecation to improve decisions regarding pellet group numbers. Freddy and Bowden (1983a) developed criteria for distinguishing among "old" and "new" pellet groups. Arthur and Alldredge (1980) provided estimates of weights of individual defecations to avoid the problem of pellet numbers per defecation. Despite this progress, more work remains to improve censuses of big game from pellet densities.

Traditionally we have assumed that the precision of deer censuses must approach ± 10 percent with 90 percent confidence, but Moore and Mills (1977) suggested that precision levels of 10–20 percent with 80 to 90 percent confidence might be more reasonable for wildlife studies. In our Colorado deer censuses, we have achieved precisions averaging 26 percent with 90 percent confidence limits from helicopter quadrat surveys and precisions of 10–20 percent with 90 percent confidence limits for pellet density estimates.

As mentioned, historically in Colorado we set the game management unit as our level of sampling resolution. More recently, we have identified the data analysis unit (a composite of game management units) as the geographic entity to which all estimates should apply. Data analysis units vary from several hundred to several thousand square miles in size and contain a heterogenous array of habitat types and physiographic complexity.

Typically, wildlife managers in Colorado have attempted to inventory big game species—particularly deer, elk, and pronghorn—every year. This obviously is an expensive task. Expansion of census systems to additional data analysis units and rapidly escalating costs of aircraft rental and labor have imposed limits on our ability to expand our big game census activities.

Colorado is now reexamining census traditions to see if acceptable trade-offs among precision, resolution, and frequency can be developed without diminishing accuracy.

Potential Improvements of Colorado's Deer Monitoring System

Improvements in Colorado's deer monitoring systems most likely will result from: (a) development of correction factors for methodological biases, and (b) optimizing trade-offs between census precision, resolution, and frequency. Research is currently being planned to examine biases in aerial surveys. We intend to use known numbers of marked animals in these tests to examine the extent to which we miscount this known population and then extrapolate to larger, unknown populations. We also need to examine potential biases related to observer differences, variations in animal distributions, weather, and counting conditions. Developments in remote sensing technology may minimize the impacts of several of these methodological biases (Wyatt et al. 1980).

Several alternatives involving census precision, resolution, and frequency tradeoffs seem apparent. For example, precision may be increased through refinements in stratification and sampling logistics without increases in sample intensity (Freddy and Bowden 1983b). As another example, we might develop census systems for larger areas wherein we sacrifice resolution but maintain or improve precision. A third alternative might be to decrease census frequency from annual censuses to censuses every third or fifth year. Interim values could be simulated and simulations would be recalibrated with each new census. All of these decisions regarding trade-offs among census precision, resolution, and frequency are management decisions.

Candidate Monitoring Systems For Elk and Pronghorn

Elk

Up to this point we have focused attention on Colorado's system for monitoring deer. What about development of systems for other large mammals in Colorado? The Research Section is currently investigating new approaches to the census of elk and pronghorn. The gregariousness of elk poses serious problems to designing adequate sampling strategies to enumerate them. To overcome this problem we have investigated the potential of mark-recapture methodology to estimate numbers of elk in Rocky Mountain National Park (Bear and Green 1980). The approach is to randomly trap and mark individual elk with colored ear tags. The trapping effort covers the entire wintering area and is done with modified clover traps (Clover 1956). An attempt is made to capture approximately 10 percent of the estimated herd. The recapture effort is accomplished by covering the entire winter range with a helicopter as soon after the trapping effort as possible, counting all ear-tagged individuals to determine the ratio of marked to unmarked animals. Three to four individual recapture flights are made each year. Precision of the system is quite high (SE $\pm$ <5 percent). Accuracy is unknown, but the estimates agree very well with life table analyses, other aerial counts, and Park Service guesstimates. Future plans call for further testing of the system in another area, with possible modifications in sampling design to ensure inclusion of the entire herd unit in both the capture and recapture effort.

Pronghorn

Pronghorn censuses in Colorado are still mired in the era of total enumeration. Consequently, they are characteristically expensive and labor intensive. Most improvements in pronghorn censuses have concerned themselves with tests of the most effective width of sample units (Larsen 1967, Elliott 1968, West 1969). Recent research in Colorado has begun to address sampling alternatives to total enumeration (Pojar et al. in press). Comparisons have been made between estimates of total population size based upon sample strips and sample quadrats. Future plans call for application of mark-recapture methodology to develop correction factors for miscounting biases similar to work done by Caughley and Grice (1982) for emus in western Australia.

Epilogue

Throughout this paper we have stressed Colorado's management and research experiences as we have worked toward continually improved big game monitoring systems. Without perspective it is easy to misinterpret our message as self-aggrandizement. In concluding, we would like to put our remarks in a more balanced perspective. We do not wish to imply that Colorado alone has been the innovator in big game monitoring systems. Even a superficial review of literature would belie that impression. Our progress in Colorado was bought with the collective efforts of wildlife scientists and wildlife managers throughout the world.

We think Colorado's big game monitoring experience is exemplary for at least three reasons. First, Colorado has reached the point of implementing a statewide deer monitoring system because of close cooperation between wildlife research and wildlife management personnel. Future improvements in the system will result from a continuation of that cooperation. Secondly, our research into census technology has been productive because we have been able to maintain research momentum over a lengthy period. Third, long-term research was possible and productive because the Colorado Division of Wildlife programmed constant and continuous infusions of fiscal resources into the research process. This allowed knowlege to accumulate slowly but steadily over time, and each new step in the research-management interface could be built upon the accomplishments of the past. Progress is the cumulation of several tiny, tentative steps forward. Each step depends upon a steady infusion of new knowledge conditioned by a steady, patient infusion of resources. Stop and go research-management programs are counter productive. Aldo Leopold once remarked "Facts, like pine trees, take not only rain, but time" (Leopold 1937:104).

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Fisheries Monitoring and Management in Freshwater Lakes, Reservoirs, and Ponds

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Introduction

Monitoring associated with evaluation of fishery resources in standing water takes many forms, involves many different parameters, and is done for many different reasons. The purpose of this paper is to discuss factors involved in designing and implementing the monitoring programs required to evaluate specific fisheries management programs. Specific sampling methods can be found in books by Bagenal (1978), Hocutt and Stauffer (1980), and Nielson and Johnson (1983).

The Management Objective

The acquisition of monitoring data to allow improved management of fish stocks at times appears to be a simple procedure, but most often it is in fact a formidable challenge. Clearly, such data can be collected from any system, but the challenge is to collect those data required for optimal management of the fishery in question at the least cost. The success of any monitoring program is related directly to the degree of definition of the management objective relative to the system to be managed and to our ability to collect the data required to implement the particular management objective while staying within funding and personnel limits.

Many different but interrelated factors must be considered in planning any field evaluation of an aquatic system. Obviously, the field measurement program cannot be formulated intelligently until a specific reason for the study has been defined. Selection of measurement parameters is dictated by the objective of the study and the time, personnel, and equipment available for data collection. The measurement scheme chosen influences the sampling program, but the availability of sampling gear and the ability to collect representative data also limit the measurement program. Thus, the objective must be well defined, and all facets of the investigation must be considered prior to sample collection.

The formulation of a management objective for any given fishery requires careful balancing of four factors, all of which interact with the fishery in the manner shown in Figure 1. As such, the management objective for the fishery must be a balance of the ecological limits to the fishery; the social, economic, and political pressures; the monetary, personnel, and equipment resources available; and the quality and quantity of data required to evaluate the success of the management program. Attention given to the limits imposed by the myriad factors involved with each of these four areas and the interplay between them dictate the probability of success of the management program selected.

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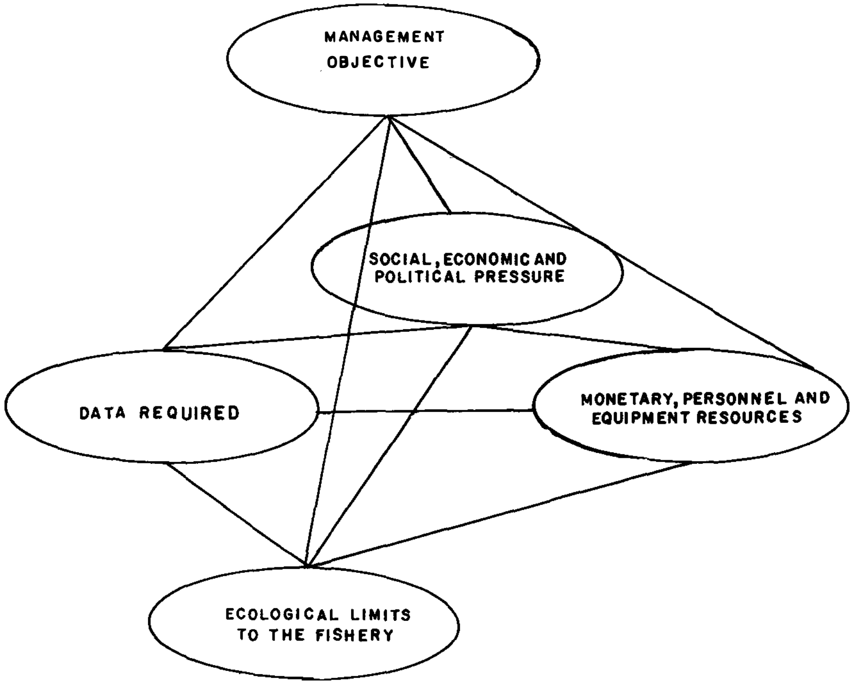

Figure 1. Factors involved in setting management objectives.

The fiscal and personnel resources available often are dependent on public interest in the fishery, with a high degree of public interest translating to an increase in such resources. Regardless of how this balance is struck, the first prerequisite to any monitoring program is a clear statement of the management objective. Monitoring without a clearly defined management objective is of little value, but poorly monitored management usually is equally futile.

Selection of specific management objectives is especially difficult under our current overriding philosophy of maintaining optimum sustainable yield. As management philosophy changed from maximizing yield— basically a biological venture—to one of providing optimum benefits to humans—a biological, sociological and economic venture—increased complexity was added. To meet these new management goals, fishery managers need to understand and pay heed to the wishes of the public, a trying situation for those trained as biologists. Evaluation of the sociological and humanistic aspects imposes additional monitoring needs to ensure that emphasis is given to broad-based public desires rather than to the wishes of a vociferous minority. The collection of such data represents a challenge best left to those with considerable education and experience in the sociological and humanistic areas. However, requirements to include public wishes in management decisions and the resultant establishment of monitoring programs in this area, staffed by people with the required expertise, compete with what is thought of as conventional fisheries monitoring for fixed or declining monetary and personnel resources of the various agencies. Although such competition at times is intense, the management program negotiated is no better than the quality of the database in areas involved relative to the management objective.

Limits to Monitoring for Fisheries Management

The first prerequisite of any management scheme is acquisition of a base description of the fishery in question. The methods used to collect such survey data depend on the system but must include some measure of the species, abundance, and size-distribution of the fish stocks present. Once such survey data are in hand, considerable information about the system can be inferred. Knowledge of the food, reproductive needs, and water quality required by the fish present, together with estimates of growth rates calculated from lengths, weights, and scales of the fish collected, give considerable information about the fishery.

The amount of monitoring information required for both implementation and evaluation of a management program varies greatly with the problem at hand. In some cases limited data for just the fish will suffice, but other problems require measurement of several to many different environmental or habitat variables as well.

In most cases, intense competition for resources and personnel severely limits the amount of information that can be collected. Rarely can sufficient data be obtained to allow measurement of the parameter of interest at the 0.05 level of significance, at which such data are commonly judged. Thus, management of these often highly variable systems is accomplished by measuring rates of change in the parameter of interest at significance levels considerably greater than 0.05 as a function of the management scheme employed.

Such limitation on data collection forces the fishery manager to use considerable professional judgement, an art form based on a variety of empirical indices. Examples of such indices include the morpho-edaphic index (MEI) (Ryder 1965) and the proportional stock density (PSD) (Anderson 1976, Anderson and Weithman 1978).

The MEI is the ratio of total dissolved solids, in mg/1, and the mean depth of the lake. This simple and inexpensive measure yields a rough approximation of fish yield from lakes and reservoirs, generally accounting for 60 to 78 percent of the variation in fish yield from lake to lake.

If a species is known to be abundant in a lake, the balance of the population and its relative worth to sport fishing can be estimated by the PSD. This index relates large and small fish in the manner shown below

$$\text{PSD (\%)} = \frac{\text{Number} \geq \text{quality size}}{\text{Number} \geq \text{stock size}} \times 100$$

All one needs to calculate the index is a definition of minimum lengths for quality and stock-size fish and a length frequency distribution of the stock. Anderson arbitrarily chose the minimum total length for the stock of all species to be some length within 20–26 percent of the world record length, and minimum length for quality size was defined as some length within 36–41 percent of the world record length.

We feel that the definition of stock and quality size may need revision depending on the species in question and the fishing clientele, but believe this index is a simple and informative management tool useful in evaluating the health of the fishery and benefits provided to the public, all calculated from a minimum amount of monitoring data.

The PSD is both time and personnel efficient. This index, when coupled with sequential sampling, yielded PSD values that were 90 percent of the true PSD using 23 to 100 stock-sized fish, depending on the balance of the system sampled (Weithman et al. 1981). Less than two person-days would be required for data collection for calculation of PSD from most lakes.

Monitoring Requirements for Management Problems

As the goal for most, if not all, fisheries management agencies is to have "good fishing," the managers' problems come when the public perceives poor fishing conditions in lakes, reservoirs, or ponds. Selection of management options to accomplish the primary goal of improving fishing depends on the situation, but in all cases requires a census of the number, species, and size distribution of fish present. This can be done with chemicals, electrofishing gear, and entrapment nets. We caution against the use of chemicals and gilling type nets as these may cause significant damage to the existing fish populations and often cause public relations problems as well.

The presence of adequate populations of small sizes of the fish of import suggests that a change in size or bag limits may yield the desired result. In this case, continued monitoring of number, species, and size distribution of the fish should yield sufficient data to evaluate the efficacy of the management options chosen. Increase in those monitored parameters of interest indicates that the management program should be continued, but no change in the measured parameters suggests that the management program should be altered.

If the preliminary census indicates inadequate populations of the fish of interest, a more detailed monitoring program must be instituted. Inadequate fish populations may be a function of overfishing, inadequate habitat, or competition from other fish species, and data on each of these variables must be obtained. Creel census may yield a sufficient estimate of fishing pressure, and an estimate of competition between fish species can be made from measurements of the number, species, size distribution, and growth rate of the fish present. Evaluation of the habitat relative to the fish in question is a more formidable challenge. Measures of the various physical, chemical and, perhaps, biological characteristics of the habitat may exceed the time and abilities of the fishery manager, and the required data may have to be collected by other groups within the agency.

If evaluation of the base data indicates excess fishing pressure, reduction in fishing effort should show increases in numbers of the fish of import. If a competing species appears to be limiting the species of interest, mechanical, chemical or biological reduction of the competing species should yield an increase in the abundance of the species of interest. In both cases, routine monitoring of the number, size structure, growth rate or PSD of the species in question should be sufficient.

If the base data indicate an inadequate habitat for the desired species, little can be done in most cases, and continued monitoring for that species is not necessary. In this case it may be desirable to introduce a new species, but this management decision introduces a whole new series of monitoring requirements. In this case we need data on critical physical and chemical variables relative to the tolerance of the introduced species to evaluate its potential to do well in the lake. The manager also needs biological data to evaluate both food availability and the potential for undesirable competition between the species to be introduced and populations of existing species. If the introduced species reduced the harvest of other species, the manager may well be trading one headache for another for quite an expense in time and money.

Once this pre-establishment stage has been determined, and the results are favorable for introducing the new species, a study of the establishment phase needs to be conducted to determine the harvest potential for the new species, given the productive capabilities of the lake. Measures of numbers, sizes, and growth rates again are critical, with food habits and fecundities of secondary importance. Once the fish have reached a fishable size, a continued monitoring of numbers, size and growth in conjunction with a creel census is needed to analyze catch rates, size of catch, and angler satisfaction. Although this is an expensive and ecologically uncertain proposition, the potential for success is related directly to the care devoted to planning and conducting the entire monitoring program.

The most ambitious management schemes relative to fish in lakes are represented by whole-lake renovation projects. In such efforts, improvement of the fishery is usually just one of the objectives along with improving lake clarity, reduction of aquatic macrophyte or algal growth, nutrient removal, and, at times, a general deepening of the lake. Although improvement in all of these areas is important to recreational use of the lake, each objective is of primary importance to a different clientele group.

Such increase in the spectrum of interest and the large amount of public funds required by such projects call for great increases in the amount and type of information prior to initiation of the project to satisfy sufficiently the objectives of each group to allow project initiation. Required in addition to knowledge of the type, abundance, and size distribution of the fish in the lake are measures of algal and macrophyte abundance, type, and growth rate; measures of primary nutrient budgets in the lake; invertebrate abundance; and measures of dissolved oxygen, temperature, and perhaps other chemical parameters, all as functions of time and space within the lake. In addition to such physical, chemical, and biological data, information must be obtained on both current and potential future public use of the lake in terms of both recreational and economic considerations. A description of the sampling plan and analytical needs of each of these parameters is beyond the scope of this paper, but collection of such information of a quality useful to the project requires the services of specialists in each area.

In a whole-lake renovation project, the fishery manager is but one of a group of professionals involved, and to a large extent the success of the program will be determined by the degree of cooperative interaction in planning and implementing the program and the character and quality of the data collected by each group. In many cases such cooperation is maintained until the physical renovation is completed but comes unraveled when the time comes to evaluate the true effectiveness of the management program. Evaluation of the success or failure of the entire renovation rests squarely on the quality and quantity of the data collected both before and after the project is completed. It is only through the use of such data that accomplishments relative to the various objectives can be proven.

Failed Monitoring

The greatest acceleration in recent time in the collection of survey and monitoring data from natural systems was mandated by passage of the well-meaning National Environmental Policy Act of 1969. This act required an environmental impact statement from every agency of the Federal government in advance of almost every proposed new action. Great volumes of physical, chemical, biological, sociological, and economic data were collected for many different projects. The demand for data collection was so great that numerous firms were created with the sole objective of collecting data. Too often the objective was not evaluation of the environmental impact but rather to amass sufficient data to protect bureaucratic self interest and allow a construction permit to be granted.

Although massive quantities of data were collected prior to initiation of construction of these various projects, precious few were collected after the projects were completed. Without these end data there was no way to compare the initial conjectural impact statement with the true impact of the project on the environment. We lost the opportunity to evaluate a great many different environmental management schemes and wasted monitoring resources. Fishery managers should recall this lesson and design all monitoring programs to allow full evaluation of the efficacy of each management program relative to its objectives, but to collect only those data needed.

Summary

Fishery managers are in a tough spot today. They are mandated to include fully the wishes of the public in management decisions, but, as officers of agencies charged with overseeing public natural resources, they must also protect the resources for future generations. They need more data and more expertise in more areas than ever before, and they must assemble this information with fixed or declining data-gathering resources. Their only hope for success is to operate their monitoring programs relative to thoughtful, carefully designed management objectives.

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Sampling and Estimating Fish Populations From Streams

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Introduction

Fish population estimates serve as the basis for meeting a variety of fisheries management and research needs. Population studies, biomass, survival, migration, reproduction, stocking, harvesting, regulations, economic analysis, assessments of environmental impacts, and life history studies all require or would be enhanced by population estimates. Sampling and calculation of fisheries populations must be done as accurately as possible because most fish populations tend to undergo wide fluctuations on an annual and seasonal basis, particularly in freshwater streams (Eberhardt 1978, Platts and Nelson, in press). Because of these fluctuations and the difficulty of enumerating fish in their unique aquatic habitat, special methods must be used to determine fish population characteristics.

Sampling Methods

Three groups of sampling methods are used to estimate fish populations: visual, mortality, and capture. Visual methods include the use of SCUBA or snorkle, redd counts, and direct fish counts. Visual observations are quick, easy to do, and do not require fish to be removed from the water. However, visual observations are rarely accurate and provide no way to assess the degree of error. Poor visibility is the main hindrance to fish observation. Accurate visual counts are inhibited by reflections, refractions, turbidity, some habitat types (such as undercut banks, weeds, debris, and substrate), and the simple fact that fish are adept at hiding and escaping. Except where fish are large and the water clear, visual observations are not an accurate method of obtaining fisheries population estimates.

Mortality methods for sampling fish include the use of toxicants and explosives. Among the effective toxicants are rotenone, antimycin, and cyanide. Explosives may be used at certain points along a stream (spot explosive concussion) or throughout a desired length of stream, using primacord. Mortality methods involve little or no selectivity among species or size of fish. Accurate counts, species identification, and size measurements can generally be made from readily harvestable dead or wounded fish. However, collection of fish may be hampered by the fact that dead fish often do not float (particularly when swim bladders have been ruptured) and by turbidity caused by the chemicals or explosives. Disadvantages of the mortality method are fairly obvious. Because fish are killed, this method has limited application to certain types of studies, such as one-time biomass or population estimates. Mortality sampling prevents further study of the population and necessitates the collection, removal, and disposal of dead fish. Other disadvantages of mortality methods include habitat disruption from explosives, the inhibition of fish or insect colonization due to residual toxicity, impacts on birds and mammals, and possible downstream impacts. Social and political disadvantages that accompany mortality methods perhaps outweigh the biological disadvantages. Conservation and humane groups frequently oppose the killing of animals for biological study purposes. Numerous laws govern the introduction of foreign substances into waterways and the modification of aquatic habitats. Agencies that need to be consulted for approval regarding these laws may include federal, state, and local water quality bureaus, fish and game departments, and environmental agencies, any of which may have the authority to block the use of mortality method. The disadvantages associated with mortality methods need to be carefully considered against the potential benefits when evaluating study designs.

Capture methods include the use of fish traps, gill nets, seine nets, and electrofishing. Fish traps and gill nets require that fish approach the capture site and, therefore, work best with relatively mobile or migratory fish. The use of seine nets and electrofishing equipment involves the pursuit of fish. All four methods require the capture and retention of fish. Gill netting frequently causes fatal injuries to fish and may be better categorized as a mortality method. Except for gill netting, the advantages of using capture methods include repeatability of sampling, high survival rates, accurate counts, species identifications, and accurate size measurements. Disadvantages of capture methods may include (depending on the type being used) temporary stress on fish and some selectivity among species and fish size. In small streams of order less than six as defined by Langbein and Iser (1960), having used all three methods, we prefer the capture method based on accuracy, high fish survival, repeatability, and virtually unlimited research applications. Among the available capture methods, electrofishing is preferred on the basis of efficiency. We have found electrofishing to be a highly reliable capture method when the stream banks fall within the range of the electrical field and when the stream is shallow enough to permit netting of stunned fish. Electrofishing is fast (involving pursuit as opposed to attraction), thorough (fish are immobilized by the electrode thereby preventing escape), and repeatable (any number of removals may be performed to achieve desired accuracy).

The widespread practice of electrofishing supports its usefulness to the fisheries community. However, no recognized standards exist for capture strategies based on electrofishing or for population estimates based on those captures. In some cases the estimate is determined by the sum of fish captured from each electrofishing pass. In other cases population estimates are used, often without adherence to the underlying assumptions of the method of estimation. Standardization of capture strategies and population estimates would help to ensure legitimate and accurate estimates while enhancing understanding and comparison of research involving fisheries population estimates. To estimate the number of fish in a given section of stream, we recommend the use of a maximum-likelihood population estimate based on a removal-depletion capture strategy.

The Removal-Depletion Capture Strategy

Removal-depletion methods of population estimation involve repeated extractions of animals from a given, enclosed area. The animals are not returned to the study area until all removals have been completed and tallied. In principle, the number of animals remaining in the study area will approach zero with each removal. Population estimates are made based on the pattern of sequential removals.

Biologists constantly try to produce the most meaningful results possible within a limited budget. The removal-depletion estimation method accommodates this goal by allowing any number of removals beyond two. Each removal theoretically yields narrower confidence intervals around the estimate. The flexibility of the removal-depletion method permits the biologist to balance desired results with financial limitations.

Maximum-likelihood population estimates based on a removal-depletion capture strategy assume (Zippin 1958):

1. No animals enter or leave the study area.
2. Each animal has an equal chance of being captured.
3. The probability of capture remains constant with each removal.

It is impossible in any study to fully meet these criteria because of random variation within habitats and populations. However, to ensure estimates with the highest degree of precision, it is to the biologist's advantage to make every effort to conform to these assumptions.

In a fisheries context, maximum adherence to the assumptions of maximum-likelihood estimates based on removal-depletion capture strategies should include:

1. Complete blocking of the stream at each end of the study area to prevent fish migration in or out.
2. Uniform capture effort applied in each pass.
   a. No change in voltage, frequency, or pulse width during electroshocking.
   b. No change in speed during any given pass through the stream.
3. Maintaining the same direction in all passes (upstream or downstream).
4. Use of more than one electrofishing machine in larger streams.

A mark-recapture estimate is a possible alternative to the removal-depletion, maximum-likelihood estimate. The mark-recapture method assumes no additions or deletions to the population, no marks are missed or lost at recapture, the capture probability is the same for marked and unmarked fish, and that marked fish randomly mix with the unmarked population. These assumptions are more demanding than those of the removal-depletion method. It may be optimistic to presume that no increased mortality results from marking, and it is unknown whether marks will be missed or lost, whether fish disperse randomly, and, if so, how long the dispersal will take. The accuracy of the estimate depends on the degree to which these assumptions are met. From a practical standpoint, it is inconvenient to wait a period of time between captures. In small streams we prefer to avoid these difficulties by using a removal-depletion method.

Maximum-Likelihood Estimates

The recommended statistical method of estimating populations from removal-depletion captures is the maximum-likelihood estimate. A maximum-likelihood estimate assesses the likelihood of each possible population estimate equal to or greater than the sum of all removals until the estimate of greatest likelihood is reached. Dr. Kenneth Burnham (pers. comm.) of the U.S. Fish and Wildlife Service, Fort Collins, Colorado, recently developed a maximum-likelihood estimate in which probabilities of each possible population estimate are calculated by computer. Use of a computer eliminates an immense number of hand calculations, minimizes the time required for computation, and reduces the possibility of human error. Because of the speed and precision of this method, we recommend it for use in estimating fish populations from streams.

The maximum-likelihood estimate calculations are based on the following formulas:

1. For any number of removals, T, equal to or greater than two, compute the total catch, S.

   $$S = U_1 + U_2 + \ldots + U_T$$

   where U_i equals the number of fish caught in the ith removal.

2. Define a statistic, C, to be used in determining capture probabilities and population estimates.

   $$C = 1U_1 + 2U_2 + \ldots + TU_T.$$

3. Estimate the likelihood of each possible population estimate equal to or greater than the total catch.

   a. Define an arbitrary integer, I, such that

   $$N = S + I$$

   where N is the population estimate whose probability is being evaluated and $I = 0, 1, 2, 3$, and so on.

   b. Define the capture probability, P, where

   $$P(I) = S/(C + TI).$$

   c. Calculate a summation term, H, where

   $$H(I + 1) = H(I) + Ln\,(1 + S/(I + 1)),$$ except when $I = 0$, let $H(0) = 0$.

   d. Calculate the likelihood function, L, where

   $$L(I) = H(I) + S{*}Ln\,(P(I)) + (C - S + TI){*}Ln\,(1 - P(I)).$$

   e. Add 1 to I and repeat Step 3 until $L(I)$ is maximized.

4. When $L(I)$ is maximized

   $N = S + I$ and
   $P = P(I)$,

   where N is now the maximum-likelihood population estimate and P is the estimated capture probability.

5. The variance for the population estimate is calculated

$$VAR(N) = \frac{N(1 - P)^T (1 - (1 - P)^T)}{(1 - (1 - P)^T)^2 - (TP)^2 (1 - P)^{T-1}}$$

6. The variance for the estimated capture probability is calculated

$$VAR(P) = (P/N)^2 (VAR(N)/(1 - P)^{T-1})$$

7. The chi square goodness-of-fit test is:

$$X^2 = \sum_{i=1}^{T} (U_i - E_i)^2/E_i + (S - E_S)^2/E_S$$

where E_i = the expected catch for the ith removal,

$= N(1 - P)^{i-1} (P)$,

E_S = the sum of all expected catches,

$= \sum_{i=1}^{T} E_i$,

There are $T - 2$ degrees of freedom.

Applications of the Maximum-Likelihood Estimate

Burnham's maximum-likelihood formula currently is being used to assess the effects of grazing-related habitat changes on fisheries populations in Idaho, Nevada, and Utah. Because habitat changes are sometimes subtle and because of natural fluctuations within fish populations, we found it necessary for our purposes to perform four removals for each section of stream studied. This sampling adequately narrowed confidence intervals around the population estimate. Population estimates in our study are calculated with the help of a computer software system called "Fisheries Population and Statistical Package" (FPSP) (Van Deventer and Platts, in prep.). FPSP calculates population estimates using the maximum-likelihood method, capture probabilities, condition factors, lengths, weights, and the confidence intervals associated with each. An abbreviated, interactive version of FPSP written in the BASIC language for the HP9845 mini-computer is contained in Platts et al. (1983). Similar programs that calculate the maximum-likelihood estimate have been written for the Apple III and the IBM personal computers and the IBM 4341 mainframe computer. These programs may be obtained from the authors. The ultimate goal of these programs is the comparison of population estimates from study area to study area and from year to year as a step toward the standardization of fish population estimates from streams.

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An Integrated System For Monitoring Wildlife on the Sierra National Forest

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Introduction

Monitoring of all renewable natural resources by National Forests in the United States became law with passage of the National Forest Management Act of 1976 (hereafter NFMA). Regulations and policies subsequently adopted to carry out this provision of NFMA include specific guidelines for wildlife that each National Forest must address in its Forest Land and Resource Management Plan. For example, each Forest must select "management indicator species" that represent four categories of wildlife, fish, and plant resources: (1) species on State or Federal lists of threatened and endangered species; (2) harvested species or species known to have high value for nonconsumptive recreational use; (3) species restricted to habitats likely to be significantly affected by management activities of the Forest, and (4) species considered to be good indicators of trends (in quality and quantity) in habitats important to other species. Although regulations are not explicit about how monitoring will be accomplished for most wildlife and fish species, they do require that Forests monitor population trends among all management indicator species.

Compliance with the monitoring requirements of NFMA represents a major challenge for National Forests, partly because costs can be enormous and partly because methods are still being developed. These are interrelated problems, because high cost precludes use of some methods widely used today to estimate numbers of animals, and some of the less costly methods give unsatisfactory results. Whatever monitoring system is adopted by a National Forest, it must be biologically sensible and statistically sound if it is ever to withstand a court test. It must also be cost-effective or the job will not get done.

This paper addresses these various points by giving some estimates of the real costs of monitoring population trends among bird species, by suggesting some cost-saving approaches that can be followed immediately, and by recommending longer-term approaches that can be even less costly. Finally, I describe the basic elements of the system recommended by the Interdisciplinary Planning Team of the Sierra National Forest, Region 5, for monitoring their wildlife and fisheries resources. Their proposed system meets the criteria identified in this paper as desirable in any initial monitoring system.

Implications of Monitoring All Wildlife

Excessive Costs and Personnel Needs

One can get an idea of the potential cost of a comprehensive monitoring system from analysis of the cost of monitoring population trends in a limited number of species. For this purpose, I have selected some bird species that breed regularly in coniferous forests of the western Sierra Nevada of California (Table 1). Among taxonomic classes of vertebrates, birds are probably the least costly to monitor, because they are relatively abundant and conspicuous, and because relatively simple methods have been developed to estimate their numbers.

The cost of monitoring bird populations is largely determined by the average number of individuals detected in a standardized set of sample counts. For bird counts exhibiting a Poisson distribution, as counts of many bird species do, the number of counts required per year to detect yearly changes in population densities of most species is prohibitively large (Dawson 1981). For example, if one detects an average of one bird per count of a given species, it would take 12,300 counts per year to detect a 10 percent yearly change in estimates of population density (Table 2). And even then, one would fail to detect such a change 20 percent of the time (Dawson and Verner in prep.).

Using 10-min point counts (Reynolds et al. 1980), we find that most bird species in the western Sierra Nevada give average counts of less than one (Table 1). In fact, for those species likely to be of special concern to us, such as the willow flycatcher or pileated woodpecker, the number of counts needed annually to detect a 10 percent change in the population is more on the order of 300,000. If one observer could complete 20 counts per day, the number of counts would require 15,000 observer-days. Assuming a salary of an entry-level biological technician

Table 1. Mean counts of selected bird species during 10-min counts at points along meadow-edges (104 sites, 171 counts) and in unlogged mixed-conifer forests (10 sites, 190 counts.)

Meadow-edge sites		Unlogged forest sites	
Species	Mean count	Species	Mean count
Dark-eyed junco *(Junco hyemalis)*	1.52	Dark-eyed junco *(Junco hyemalis)*	1.32
Western wood-pewee *(Contopus sordidulus)*	1.15	Nashville warbler *(Vermivora ruficapilla)*	1.08
Yellow-rumped warbler *(Dendroica coronata)*	1.10	Steller's jay *(Cyanocitta stelleri)*	0.66
American robin *(Turdus migratorius)*	1.09	Mountain chickadee *(Parus gambeli)*	0.40
Steller's jay *(Cyanocitta stelleri)*	0.36	Golden-crowned kinglet *(Regulus satrapa)*	0.25
Warbling vireo *(Vireo gilvus)*	0.33	American robin *(Turdus migratorius)*	0.18
Wilson's warbler *(Wilsonia pusilla)*	0.28	Hairy woodpecker *(Picoides villosus)*	0.14
Yellow warbler *(Dendroica petechia)*	0.13	White-headed woodpecker *(Picoides albolarvatus)*	0.12
Willow flycatcher *(Empidonax traillii)*	0.04	Pileated woodpecker *(Dryocopus pileatus)*	0.03

Table 2. Counts per year needed to detect yearly changes in population densities. Tabled numbers of counts will result in Type I errors 5 percent of the time and Type II errors 20 percent of the time (based on Dawson and Verner in prep.).

Mean number of birds/count	Percent difference between populations		
	10	25	50
10	1,230	197	50
1	12,300	1,968	492
0.1	123,000	19,680	4920
0.01	1,230,000	196,800	49,200

(GS-5, Step 1), this comes to an estimated $825,000 per year. Because the suitable counting period for any given season is limited to about 60 days, the effort would require 250 temporary employees, all capable of locating the counting points quickly and all capable of recognizing the bird species by sight and sound. Not only are the cost and personnel needs for such an effort out of reason, but also it is unreasonable to expect to find such a large number of counting points, because each must be independent of the others to satisfy assumptions of the statistical models. This fantasy can be extended to include all of the various species we may be concerned about and in all of the various types of habitats where they may occur. Obviously other approaches are required.

Reducing Costs and Personnel Needs

Look only for declining trends. The model used in the previous example seeks to answer questions about any change in the relative density of a population from year to year, whether an increase or a decrease. The critical need for land and resource managers, however, is to be aware of significant *declines* in populations. Only in exceptional circumstances will a significant increase in the numbers of some animal species be cause for corrective management action.

Random sampling errors in monitoring animal populations have two important implications for managers, even when the monitoring system is designed specifically to detect only declining trends. First, one could conclude that a population declined when it did not (Type I error of statistics). Additional funds may then be spent unnecessarily to further study a stable population. Although potentially costly, Type I errors are not the most serious. Second, one could conclude that a population is stable when it has really declined (Type II error of statistics). In this case, one would not know that further study may be needed. This is potentially a more serious error and one that monitoring systems should be designed specifically to minimize. The frequency of Type II errors may be decreased by increasing the sample size, which necessarily increases the "power" of statistical tests. With a power of 0.6, for example, one will fail to detect a specified decline in populations 40 percent of the time. This is not good enough. A power of 0.8 (failing to detect specified declines 20 percent of the time) may be a good compromise in terms of tolerable costs and adequate safeguards against creating more endangered species.

Dr. F. N. David (in prep.) has developed a statistical model sensitive to proportional declines from the initial year in measures of a species' abundance, assuming that counts fit a Poisson distribution. Potential cost savings from this restricted alternative vary with the desired power of the test (ability to avoid a Type II error) and the magnitude of the decline one wishes to detect. Consider a species that averages one bird per count. To detect a 25 percent decline in its population, the number of counts needed per year ranges from 93 for a power of 0.5 to 250 for a power of 0.9. Corresponding sample sizes if one wishes to detect *any* change of at least 25 percent, i.e. either an increase or a decrease, are 362 and 2707, respectively (Figure 1). Savings using year-to-year declines range from 74.3 percent to 90.8 percent.

The David model applies specifically to counts fitting a Poisson distribution. For those species shown to fit other distributions, appropriate statistical models for detecting declines in population numbers undoubtedly would also permit substantial cost savings compared to the more general question of detecting any change in numbers from one year to the next. The primary requirement of these models is that counts be rigorously standardized to assure that they are done comparably every time. The following guidelines are suggested for monitoring birds, just to give some idea of the sorts of items that need to be standardized. Specifically:

1. The counting period must be fixed and precisely observed. The point-counting method of Reynolds et al. (1980) is recommended, and the count period should be at least 5 min and at most 10 min in duration (Dawson and Verner in prep.). The higher the average count of any given species the better, so longer counts may be preferred. However, in foothill woodlands of central California we find that 5-min counts give average counts as high as 8-min counts (Verner in press). Some preliminary sampling should be done to determine the best compromise between longer periods for higher counts and shorter periods to save time.
2. The same points must be counted every time. In the event a point is lost because of a major change in the habitat, another comparable point may be selected, but year-to-year comparisons must include only those points that were counted in every year to be compared. If one anticipates a relatively high rate of loss of points, the total number counted must be increased to allow for this in the analysis.
3. Counts should be done at the same time each year, both in relation to time of day and season. The best time of day will vary from area to area, but early morning—to about 4 or 5 hours after dawn—is generally best (i.e., will give higher counts of most species). The season each year should be determined by phenology, not the calendar.
4. Observers should be competent. This will require testing (e.g., ability to identify birds, hearing ability, reliability) and training with regard to birds in the specific area to be sampled, as songs even of the same species vary from place to place.

Select "high-probability" sites for management indicator species. Most management indicator species are relatively uncommon; indeed some are selected because they are rare, threatened, or endangered. Therefore, average counts of such species are generally so low in a randomly selected set of sampling points that cost precludes sampling enough points to detect declining trends with statistical confidence. A pre-monitoring inventory can be used to identify places in which these species are consistently found, and their monitoring can then be accomplished by repeated sampling just of those places. For some species this

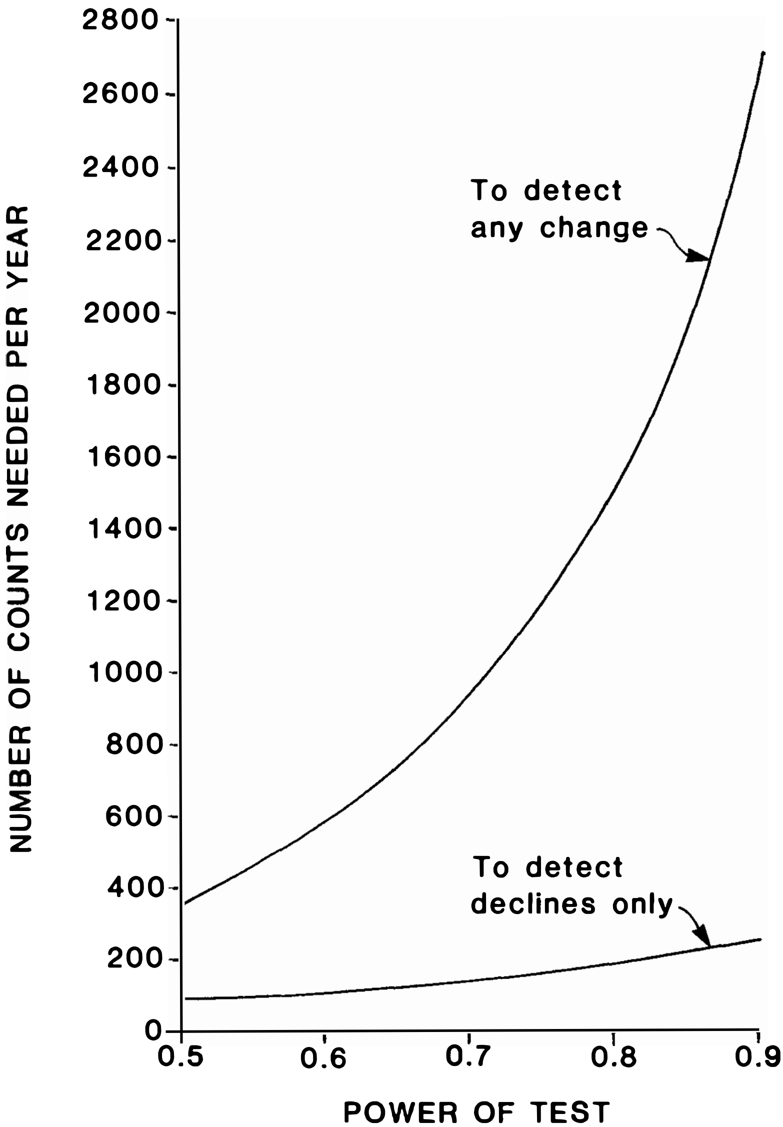

Figure 1. Number of counts needed per year to detect a 25 percent decline in numbers, as a function of power to avoid Type II errors, when the mean number counted in the first year is 1.0.

may result in monitoring essentially the total known population, and statistical analysis may be unnecessary. For others, although the total population is not monitored, the number of sites available for sampling on a given National Forest may be insufficient to permit rigorous statistical analysis. Combining data from two or more adjacent National Forests may be a feasible alternative, and for some species, such as the spotted owl *(Strix occidentalis)* in Region 5, it may be appropriate to combine results over a whole Region to evaluate trends and make judgements about the viability of populations.

Monitor "management guilds." A guild, as originally proposed and defined by Root (1967:335), is a "group of species that exploit the same class of environmental resources in a similar way." The idea of grouping species to aid in understanding the effects of management activities on wildlife species has been developed through the papers of Haapanen (1965), Jarvinen and Vaisanen (1979), Thomas et al. (1979), Verner (1980a), DeGraaf and Wentworth (1981), Severinghaus (1981), Short and Burnham (1982), Landres (in press), and Verner (in press). A "management guild" is defined as a group of species that respond in a similar way to changes in their environment (Verner, in press).

Most workers have grouped species according to major zones of a habitat used for nesting or feeding. Short and Burnham (1982) developed a two-dimensional matrix with axes identifying primary feeding and nesting zones. Application of a similar matrix to the bird assemblage in a pine-oak woodland of the western foothills of the central Sierra Nevada identified primary feeding zones as ground, shrubs, tree boles and limbs, tree canopies, and snags. The same zones identified primary nesting zones, and a "breeds elsewhere" category was added to deal with transients and winter residents (Verner, in press).

The primary use of such management guilds should be to monitor trends in the suitability of various zones of a habitat to support wildlife species. As such, guilds will probably make their greatest contribution to a monitoring system as indicators of the quality and quantity of certain habitats that are most likely to be changed by management activities. Additionally, however, monitoring of management guilds can tell us much about the whole assemblage of birds, about certain individual species, and even about possible factors involved in observed declines, as explained below.

Certainly a major advantage of guilds in a monitoring system is that a group of species yields a higher count than any single species, which reduces the number of points that must be counted to obtain an adequate sample. For example, in the case of the pine-oak woodland cited above, the plain titmouse *(Parus inornatus)* is the most abundant species, with an average of 1.36 birds per 5-min point count. It belongs in the nesting guild that uses tree boles and limbs, which had an average combined count of 4.22. Its feeding guild, which uses tree canopies, had an average count of 3.57. It thus costs only about a third as much to detect a significant decline in the guild as it does for the titmouse alone.

A second advantage to monitoring guilds is that one obtains a more complete listing of the bird assemblage each time the habitat is sampled than would result if only one or a few management indicator species were counted. But *the cost of obtaining the more complete list is no greater than tallying just one or a few species,* because an observer can easily record all birds detected during a visit to a counting point. The more complete list at least gives the manager an opportunity to look for a marked decline in numbers or perhaps even the disappearance of any individual species. Even though sample sizes may result in low power, just a hint that something may be going wrong can alert the manager to consider further study.

Still another advantage to the guild approach is that one can group species in a variety of other ways to give evidence on specific questions. For example, if a significant decline is found in one or more guilds, one could group species according to residency status to see whether such groups differ in reflecting the decline. Suppose that a group consisting of all the permanent residents (those species present in the area all year) has not declined, but the group including all migrant breeders has. One could argue that the problem is on the migration routes or wintering grounds of the migrant breeders, and that conditions in the breeding habitat are unchanged. A converse finding—i.e., that permanent residents have declined but migrants have not—could indicate a problem during the winter for the permanent residents, but not during the breeding season.

Use single-season monitoring. Ideally, monitoring should account for a species' needs throughout the year, but to do so would require at least four repetitions of the monitoring effort each year. I previously suggested that, at least for birds, monitoring only during the breeding season should be adequate (Verner 1980b). Adoption of this recommendation would reduce potential costs of monitoring by perhaps as much as 75 percent. If transients and winter residents use the same zones of a habitat for feeding and cover in basically the same ways as the breeders do, maintenance of the populations of all breeding species should ensure maintenance of suitable habitat for transients and winter residents. This is only a hypothesis that needs to be verified. However, it was supported by data on foraging behavior of breeding, transient, and wintering species of birds in pine-oak woodlands of central California (Verner, in press).

Monitor trends in habitats. If we knew enough about the habitat needs and tolerances of all species of wildlife, we should be able to infer trends in their population sizes by monitoring trends in habitats. This concept underlies development by the Forest Service of extensive wildlife-habitat relationships models, following the lead of Patton (1978) and Thomas et al. (1979). Experience has shown, however, that we still have much to learn about the relationships of vertebrate species to their habitats. The models presently in use today need testing, verification, and correction. And we need to develop suitable computer models for interfacing predicted trends in habitats with those of wildlife populations. Ultimately, however, it should be possible to effectively monitor trends in wildlife populations almost exclusively through habitats. This will be the most cost-effective method, because trends in habitats must be monitored for information on timber resources. Thus, the cost of monitoring wildlife trends can be largely absorbed by monitoring timber resources.

An Integrated System For Monitoring Wildlife Populations

The various methods discussed here for monitoring trends in wildlife populations can be integrated into a dynamic and cost-effective system that can lead to further efficiency and cost-effectiveness (Figure 2). The ultimate goal should be a system permitting most monitoring of wildlife resources indirectly by monitoring trends

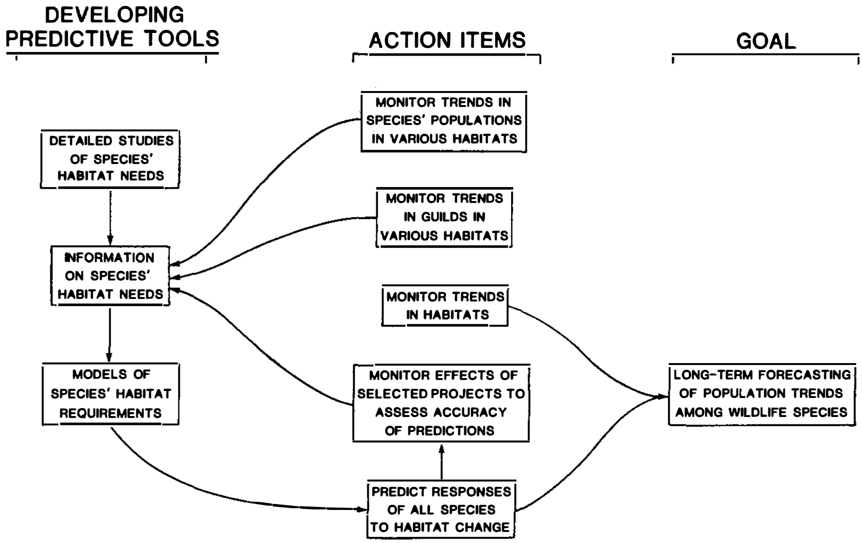

Figure 2. Flow chart depicting interrelationships among elements of an integrated system for monitoring wildlife populations.

in their habitats. This depends on development of accurate models of species-habitat requirements from information on species' habitat needs. Initially this information would come from detailed studies of the species themselves. As a monitoring system is put in place, however, we will learn more about species' habitat needs from direct monitoring activities—of the populations of selected species, of management guilds, and of the effects of selected projects on wildlife populations.

Continual feedback of this new information into the wildlife-habitat relationships models should improve the accuracy of our predictions about effects of projects on wildlife and of long-term forecasting of population trends among wildlife species. Eventually it should be possible to phase out most of the direct monitoring activities.

Case Study: The Sierra National Forest

A monitoring plan for wildlife resources, as recommended by the Sierra National Forest's Interdisciplinary Planning Team, has been designed to reflect all components of the integrated system briefly described in the previous section of this paper. In addition, it recommends five years of inventorying prior to commencement of monitoring to provide baseline data for use in evaluating results of monitoring activities. It is reviewed here as one example of a promising monitoring plan to be tried and evaluated.

The number of management indicator species identified in the Sierra National Forest's Plan is the minimum sufficient to comply with the law. Named species are Lahontan cutthroat trout *(Salmo clarki henshawi),* Paiute cutthroat trout *(Salmo* *clarki seleniris),* rainbow trout *(Salmo gairdneri),* bald eagle *(Haliaeetus leucocephalus),* peregrine falcon *(Falco peregrinus),* spotted owl *(Strix occidentalis),* and mule deer *(Odocoileus hemionus).* The recommendation calls for monitoring the Paiute cutthroat trout every five years as long as its habitat remains in wilderness, the rainbow trout and spotted owl every two years, the Lahontan cutthroat trout annually for two years then every two years for as long as management activities occur in their watershed, and annually for all other named species. In each case, except for mule deer, monitoring would include surveys by personnel of the U.S. Forest Service. Information from other agencies would be added when available, and cooperation with the California Department of Fish and Game will be necessary to conduct some of the surveys.

The plan recommends monitoring, every two years, of management guilds of birds in three habitats especially vulnerable to management actions—late-successional mixed-conifer forests, riparian habitats, and at meadow edges. The intensity of human activities in these habitats makes them appropriate ones in which to use a guild approach for monitoring. Restriction of the monitoring to birds assumes that stability in the assemblage of birds can be taken to indicate similar stability in the assemblages of amphibians, reptiles, and mammals. Because the whole assemblage of birds is monitored, this is more likely to be true than if only one or a few species were monitored; however, the validity of this assumption needs testing. The Forest plans to monitor effects of selected projects, on an ad hoc basis, to test this and other assumptions about the whole monitoring plan.

Monitoring of most wildlife species in most habitats would be accomplished by monitoring trends in habitat diversity—the mix of different habitat types identified as important to wildlife (Verner and Boss 1980). Those trends, together with information from the wildlife-habitat relationships system, should permit an adequate assessment of trends for most species of wildlife, especially the more common and widespread ones. Species most likely to be negatively affected by major land management activities on the Sierra National Forest would be more directly monitored through management guilds or other appropriate methods. Species dependent on late-successional stages of red fir forests, which are only now beginning to be harvested in a major way on the Sierra National Forest, may require special monitoring in the future, as by management guilds. Most other species find suitable habitats in secondary successional stages of coniferous forests, or in mountain chaparral habitats not likely to be reduced in extent in the near future.

Compliance with Regional and Forest standards and policies concerning retention of snags and downed logs would be monitored annually.

Finally, although not identified as a part of the monitoring plan, effects of selected projects would be assessed through inventories of various resources. Inventories would be done as regular project activities, and results could be fed back into the information system used to predict project effects, thus improving the accuracy of later predictions.

The wildlife monitoring system, as proposed, would add an estimated $18,600 to the annual cost of doing business by the Sierra National Forest. This includes the estimated cost of management, analysis, and interpretation of the data obtained from monitoring. Some costs may be reduced by cooperatively undertaking the monitoring of management guilds with adjoining National Forests. An effort of this sort may be required if enough sampling points cannot be located on the Sierra National Forest.

Although it is not identified in the proposed plan as a direct cost of monitoring, the start-up cost of the proposed plan would be substantial. For example, pre-monitoring inventories of management indicator species, such as the spotted owl, would be essential to the design of a cost-effective monitoring program for these species. Before monitoring of management guilds could begin, a sufficient number of counting points must be located in each of three vulnerable habitats. The goal is 200 points in each habitat, and selection of the points must conform to certain constraints of statistical analysis. And baseline counts, estimated to cost $120,000 over a 5-year period, will be conducted in each habitat type for five consecutive years before monitoring begins. Those costs will be charged to appropriate resource areas. Finally, monitoring of the effects of specific projects has been budgeted as a project cost rather than a monitoring cost, even though such information is central to the whole monitoring process. It is evident that implementation of this plan by the Sierra National Forest would result in a substantial but reasonable commitment of resources to comply with NFMA regulations.

Conclusions and Recommendations

The plan for monitoring wildlife resources, as recommended by the Interdisciplinary Planning Team of the Sierra National Forest, is reasonable and realistic. It recognizes the need to provide a biologically sensible and statistically sound system that is cost-effective. To achieve this, the plan has integrated monitoring at three levels: (1) Species—only those management indicator species as required by law; (2) management guilds—guilds of birds in three habitats especially vulnerable to change through human activities; and (3) habitats—most wildlife species would be monitored by inference from trends in habitats (already monitored for timber resources), based on knowledge of each species' habitat requirements.

Level 3—monitoring of habitats—should be viewed as the eventual goal for nearly all monitoring of wildlife resources, because it is the least costly. Only experience, however, will be able to show whether this can give us sufficient accuracy in our predictions of long-term trends to ensure that we maintain viable populations of all wildlife species, as required by NFMA. I believe that the integrated system proposed for the Sierra National Forest could meet this goal. It appears to be conservative enough to assure early detection of any serious decline in numbers of any species, and provides a number of feedback mechanisms to continually improve the accuracy of the wildlife-habitat relationships system. Without this, we could never rely on a knowledge of trends in habitats as a way to monitor trends in animal populations.

Use of the habitat approach to monitoring wildlife still has weaknesses that must be addressed. The major ones are annotated here. Items in the following list are not arranged in any order of priority, as each deals with a critical subject:

1. The key to the whole system lies in a reliable, computerized record of all habitat polygons over the entire National Forest. Any change in the habitat of a polygon must be dutifully recorded in the data file, and a periodic analysis of all changes and their effects on wildlife will be required.
2. Ideally, all users should follow the same system of habitat classification. Until

such an ideal is reached, however, all should at least use a system that can be easily translated into other systems in use.

3. Information about the habitat requirements of wildlife must be accurate. This is a relatively new approach to wildlife management, so information in existing wildlife-habitat relationships systems is undoubtedly weak in some areas. Directed research, together with well-designed monitoring programs, will be needed to give these systems the required accuracy.
4. Efficient operation of the system will require sophisticated computer capability. We need verified models that can accurately forecast trends in habitat conditions and integrate these with wildlife-habitat requirements to forecast trends in animal populations. This will require the cooperative research of specialists in silviculture, wildlife biology, statistics, and computer science.
5. We need better information on cost-effective, statistically sound methods of estimating numbers of animal populations. This is primarily a research problem, but I see many opportunities to coordinate the research with ongoing monitoring programs on National Forests.
6. We know little of the effects of polygon sizes, shapes, and arrangements on wildlife populations. Research in this area seems to be very slow in coming, but it is critical if we are to use a habitat approach to monitoring wildlife populations.

Monitoring of renewable natural resources on a scale required by NFMA brings a whole new set of challenges to the National Forest System. Our first efforts must be viewed as optimistic and exploratory. I believe the system proposed by the Sierra National Forest to monitor its wildlife resources is both sensible and reasonable, but it may be far from the system that will eventually emerge as an accepted standard for all National Forests. Other Forests will try other systems, and rightly so. All systems should be studied carefully to learn how well they meet the stated goals of NFMA, and all should have the flexibility to allow changes that promise to improve the quality, or reduce the cost without sacrificing quality, of monitoring wildlife resources.

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Habitat Suitability Indices For Monitoring Wildlife Populations—An Evaluation

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Introduction

Production of wildlife and wildlife habitat traditionally have not been evaluated as viable land use alternatives. This has changed in recent years, primarily because of the passage of the Fish and Wildlife Coordination Act of 1934 and the National Environmental Policy Act (NEPA) of 1969. NEPA requires that potential adverse impacts on fish and wildlife be considered for projects proposed or under consideration, which require federal funding or a federal permit. Thus, NEPA created a need for a scientific system of habitat evaluation that would permit assessment of the effects of actions taken in a federal project.

Habitat Evaluation Procedures (HEP) were developed by the U.S. Fish and Wildlife Service (FWS) to provide a habitat-based approach for assessing environmental impacts of proposed water and land resource development projects. This system is based largely on one developed by Daniel and Lamaire (1974) in Missouri and is often used in mitigation and compensation proceedings currently being implemented in several regions throughout the United States.

HEP is based upon life-requisite models developed for species for which the cover type is to be evaluated. HEP models were used widely before any were tested in the field. Until now the only model tested is one for the bobcat *(Felis rufus)* (Lancia et al. 1982). They found substantial agreement between radio-tracked bobcats and predicted habitat use. In general, due to the lack of field validation of HSI models, a serious flaw exists in the developmental process of HEP regarding the calibration of models as well as specific procedures for model validation.

The objectives of this project were to: (1) use HEP procedures to develop models for seven species commonly found on abandoned Appalachian strip mines; and (2) test their validity with population data. The models would then be used to evaluate wildlife habitat potential on abandoned strip mines.

Materials and Methods

Study Areas

Ten study sites were selected in Monongalia County, West Virginia, to represent various stages of succession including farm, field, or house sites, each abandoned

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for at least five years. The study sites were Fort Martin #1 (FM1), Fort Martin #2 (FM2), Fort Martin #3 (FM3), Summers School Road #1 (SS1), Summers School Road #2 (SS2), Cheat Lake #1 (CL1), Cheat Lake #2 (CL2), Route 48 (RT48), Chestnut Ridge Road (CRR), and Core (CORE).

Study sites ranged in size from 5 acres (2.0 ha) to 27.3 acres (10.9 ha). Common plants included multiflora rose *(Rosa multiflora),* blackberry (*Rubus* spp.,), hawthorn (*Crataegus* spp.), greenbriar (*Smilax* app.), sumac *(Rhus typhina),* red maple *(Acer rubrum),* elm *(Ulmus americana),* and various old-field grasses and forbs, such as goldenrod (*Solidago* spp.).

Model Species

The eastern phoebe *(Sayornis phoebe),* red-eyed vireo *(Vireo olivaceous),* prairie warbler *(Dendroica discolor),* field sparrow *(Spizella pusilla),* meadow vole *(Microtus pennsylvanicus),* white-footed mouse *(Peromyscus leucopus),* and eastern cottontail *(Sylvilagus floridanus)* were chosen to represent species common on abandoned strip mines in Appalachia (Curtis et al. 1978, Tompkins 1981). The models will be used to evaluate wildlife habitat potential on abandoned strip mines, as the vegetation is similar to that found on study sites. Models for three species (meadow vole, white-footed mouse, and cottontail) were modified from models developed by the FWS in 1978.

Model Variables and HSI Development

HEP is a means of quantifying habitat, habitat suitability, and the gains or losses due to specified actions. The procedure focuses on measuring various biotic components (variables) in an area and relating these to resident species through the development of Suitability Index (SI) graphs (Figure 1). Altogether, 17 variables were used in the seven HSI models, with three to six variables per species (Table 1). A value for each variable was determined for each site and the variables in each model generated SI values from the SI graphs. Values from the SI graphs then become inputs into Habitat Suitability Index (HSI) equations. Equations were derived from trial and error to provide the best possible fit to the data and varied from weighted means to combinations of weighted means and geometric means. An HSI for each species was then derived from the equation. HEP assumes that habitat can be described by the HSI. The value and reliability of HEP is based on the construction of a viable and meaningful HSI (U.S. Fish and Wildlife Service 1980).

Curves like those displayed in Figure 1 are integrated in the equation

$$\mathrm{HSI} = \frac{10V1 + (V2^{*}V3^{*}V4^{*}V5^{*})^{80} + 2V6}{13}$$

where $V1$ = % herb cover
$V2$ = % shrub cover
$V3$ = % tree cover
$V4$ = Mean herb height
$V5$ = Mean shrub height
$V6$ = Mean tree height

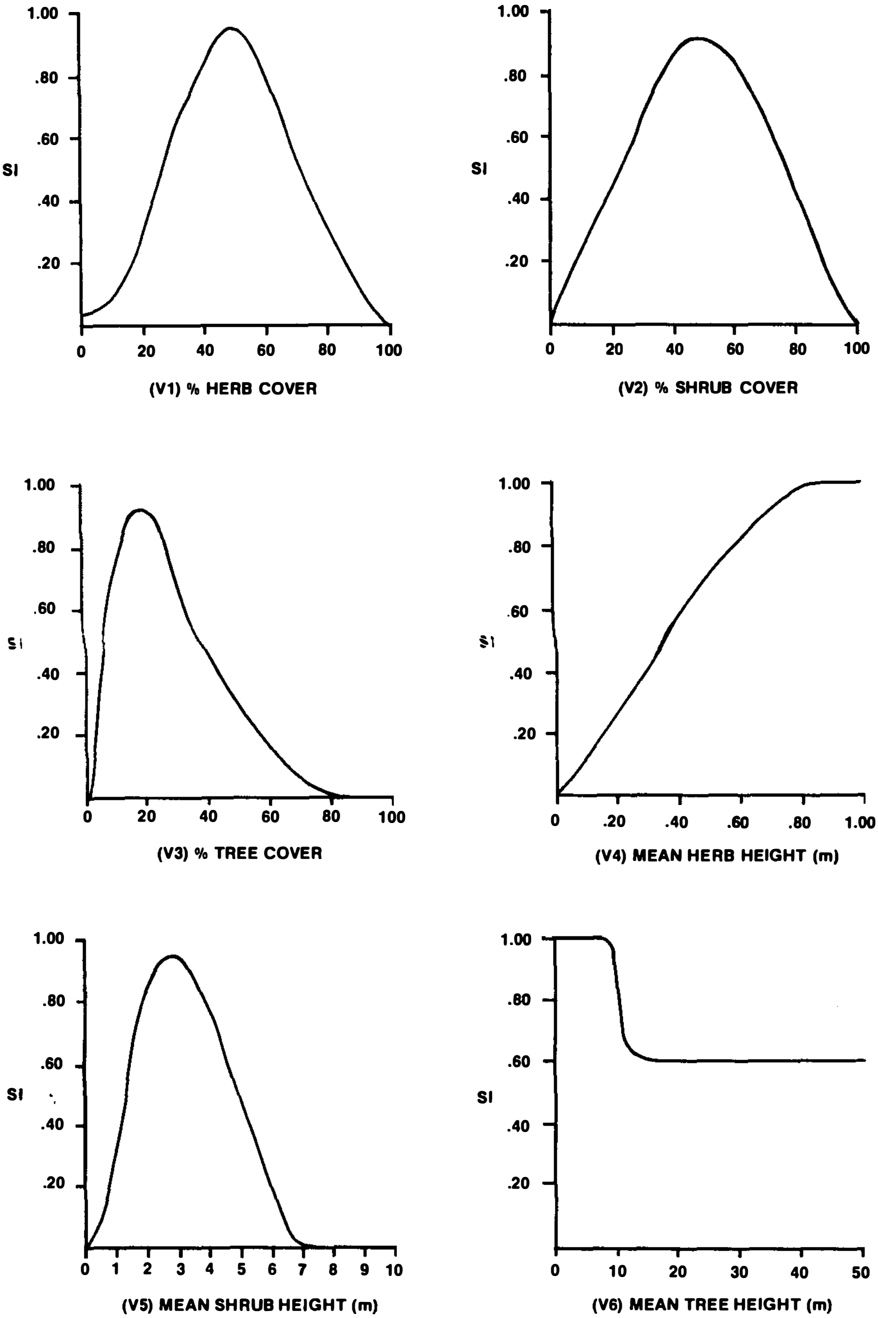

Figure 1. Suitability Index (SI) graphs for the field sparrow.

Table 1. Model species and associated variables.

Variable	Eastern phoebe	Red-eyed vireo	Prairie warbler	Field sparrow	Meadow vole	White-footed mouse	Eastern cottontail
Percent herb cover				X	X	X	X
Mean herb height				X	X	X	
Percent shrub cover			X	X		X	X
Mean shrub height				X			
Mean forest shrub height		X					
Percent tree cover	X	X	X	X			
Mean tree height		X		X			
Percent of herb canopy in grass or grass-like plants					X		
Relative soil moisture					X		
Distance to woodland or brushy cover							X
Degree of interspersion			X				X
Distance to nearest water	X						
Presence of cliffs, highwalls, buildings, bridges or mudbanks	X						
Understory characteristics		X					
Presence/absence of cowbirds			X				

The HSI index thus derived for any site represents a relative ranking of the suitability of that site for reproduction and cover for field sparrows. Equations vary from species to species and from one life requisite to another. For each species reported here, the final form of the equation was based on empirical adjustments of an initial hypothetical equation developed from the study of the literature for each species.

Sampling

Bird populations were censused in April, May, and June of 1982, and a complete count was made. The sites were small enough to accurately census each area. Each site was visited a minimum of three times, and seven sites were sampled four times. Sampling was discontinued when a running average determined that all resident birds had been located.

Small mammals were trapped using two standardized, parallel, 328-foot (100 m) traplines of 10 stations each, with three traps per station for a total of 1,800 trap nights (Golley et al. 1965). Rabbit abundance was determined using a browse index consisting of the number of browsed plants along a single 328-foot (100 m) transect.

At 32.8 foot (10 m) intervals along a single, variable-length transect, herb and shrub heights were measured in four quarters and a mean was computed for each site. Mean tree height was measured with an Abney level set at 45 degrees, so distance to the tree equalled the height of the tree. Because each study site had an even tree line, intensive sampling was not needed. Five or six trees were randomly chosen on each site.

Percent herb, shrub, and tree cover, and distance to nearest water were determined from aerial photographs and U.S. Geological Survey topographic maps. All other variables (Table 1) were measured during on-site inspections.

Statistical Analysis

Analysis of variance (ANOVA) was used to test for differences in vegetation height between study sites to determine whether ranking between sites could be attempted on that basis.

Linear regressions and Spearman's rank correlations were used to test for similarity between population and HSI rankings of sites. A significance level of 0.05, and R^2 of 0.50, and a Spearman's correlation coefficient of 0.60 were desired. These levels are those commonly seen as acceptable.

Results

ANOVA

Sites differed significantly in heights of herbs ($F = 8.49$) and shrubs ($F = 8.51$), but not of trees ($F = 1.33$) (Table 2). Enough differences existed in vegetation to rank the sites.

Population Regressions and Correlations

Population levels for the evaluation species are shown in Table 3 and HSI values are given in Table 4. The HSI's and the population data were ranked from highest to lowest. All linear regressions between HSI ranks and corresponding population ranks are significant (Table 5). R^2 values ranged from 0.48 in the field sparrow and cottontail models to 0.65 in the prairie warbler. Intercept values ranged from 0.68 for the prairie warbler to 1.72 in the red-eyed vireo model. Slope varied from 0.70 in the cottontail to 0.82 for the prairie warbler.

HSI and population ranks were correlated using Spearman's rank correlation (Table 6). All correlations were significant ($p<0.05$), ranging from 0.68 in the cottontail to 0.80 in the red-eyed vireo. Every model achieved the desired 0.60 correlation coefficient.

Table 2. Results of ANOVA for herb, shrub, and tree heights.

Variable	MSSQ[a]	ESSQ[b]	F
Herb height (cm)	9848	50240	8.49[c]
Shrub height (m)	235	1196	8.51[c]
Tree height (m)	351	1125	1.33

[a]Mean sums of squares
[b]Error sums of squares
[c]Significant at the 0.01 level

Table 3. Population levels for breeding birds (mean no. seen/day), small mammals (mean no. caught/day) and cottontails (browse signs/site).

Species	FM1	FM2	FM3	SS1	SS2	CL1	CL2	RT48	CRR	CORE
Eastern phoebe	1.80	0.50	1.00	0.00	1.30	0.00	0.50	1.00	0.25	0.67
Red-eyed vireo	3.80	0.75	0.00	5.00	9.30	1.30	5.30	3.00	1.80	6.70
Prairie warbler	5.30	3.30	0.00	3.50	3.50	3.00	3.30	1.00	0.00	3.00
Field sparrow	7.50	5.50	4.80	2.30	2.00	1.70	1.80	2.70	1.80	3.30
Meadow vole	1.67	0.33	1.00	11.33	0.67	0.67	0.67	0.67	0.00	0.00
White-footed mouse	0.33	0.33	0.67	0.00	0.67	0.00	0.67	0.33	1.67	1.33
Eastern cottontail	11	5	13	18	4	25	11	—[a]	3	19

[a]Not sampled due to the presence of cattle

Table 4. HSI values for the seven evaluation species at the 10 study sites.

Species	FM1	FM2	FM3	SS1	SS2	CL1	CL2	RT48	CRR	CORE
Eastern phoebe	0.81	0.55	0.38	0.34	0.93	0.54	0.67	0.71	0.47	0.80
Red-eyed vireo	0.62	0.47	0.25	0.58	0.72	—	0.75	—	0.24	0.62
Prairie warbler	—	0.94	0.71	0.93	0.92	0.93	0.96	0.91	0.78	—
Field sparrow	0.21	0.25	0.76	—	0.21	0.15	0.17	0.13	0.09	0.19
Meadow vole	0.18	—	0.49	0.47	0.45	0.13	0.13	0.18	0.11	0.13
White-footed mouse	0.46	0.34	0.67	0.21	0.23	0.22	—	0.38	—	0.58
Eastern cottontail	0.68	0.43	0.94	0.70	0.47	0.48	0.55	—	0.33	0.71

Discussion

Although several scientific habitat evaluation systems have been developed, HEP appears to be the one most widely used. However, critics argue that a major weakeness in the HEP methodology is in the species life-requisite models (Lancia et al. 1982). Data derived from the implementation of HEP are from HSI models. Available models were suspect because the only one tested against actual population data was for the bobcat (Lancia et al. 1982).

Table 5. Results of linear regression analyses between HSI values and population levels. All regressions were significant ($p<0.05$).

Species	F	R^2	Intercept	Slope
Eastern phoebe	8.06	0.57	0.89	0.77
Red-eyed vireo	7.53	0.49	1.72	0.73
Prairie warbler	10.94	0.65	0.68	0.82
Field sparrow	6.57	0.48	1.25	0.74
Meadow vole	9.92	0.59	1.23	0.79
White-footed mouse	5.95	0.50	1.48	0.73
Eastern cottontail	6.35	0.48	1.60	0.70

Table 6. Correlation coefficients between population data and HSI values for test species. All correlations were significant ($p<0.05$).

Species	Spearman rank correlation
Eastern phoebe	0.72
Red-eyed vireo	0.80
Prairie warbler	0.72
Field sparrow	0.71
Meadow vole	0.77
White-footed mouse	0.72
Eastern cottontail	0.68

Validation of HSI models poses several problems. In this study, one year's data were assumed to represent normal population levels. Ideally, populations should be sampled over several years. All equations developed for the HSI models were based on this assumption.

Equations also posed a problem, because the original ones developed proved almost useless when tested. Equations had to be reworked, by trial and error, until reasonable HSI values were generated. The iterative process stopped when an inflection point of diminishing return was reached. Although this type of manipulation can be questioned, we argue that the relationships were always there and equation manipulation simply tried to uncover them. An assumption must be made that the life histories are correct and that only the equations can be modified. Life history knowledge is extensive and well documented, but mathematical relationships between habitat variables are not.

A general pattern emerged in reworking the equations. For the most part, each equation was a variation of a weighted mean. Geometric means were included in three equations, but only as a member of the entire weighted mean equation. The weights for each variable were roughly determined by intuition and subsequently refined through an iterative process.

Model validation in the past has centered on species authority validation where models were reviewed by biologists familiar with the species in question. A subjective evaluation was then made as to the validity of the model. This is a deceptive and circular approach (Lancia et al. 1982). Presumably the author of the model consulted sources from various authorities before developing a model. To approach these same authorities once more is asking only for confirmation of what has already been written. That, in no way, ascertains validity of the model (Lancia et al. 1982).

The validation of models using field data is also circular but provides a more accurate preliminary model. To eliminate this problem, models, once developed, should be tested over a number of sites and years before final acceptance.

Model accuracy is also an important consideration. According to Farmer et al. (1982), models are usually complete in either breadth or depth, but rarely both. Model breadth increases as the number of habitat components included in the model increases. Habitat components include food, water, cover, and various reproductive needs. However, model depth many consider only one or two of these components and examine all aspects within them.

The models developed for this study, and throughout the HEP program, have model breadth. This approach appears to be the most realistic, given the time and money constraints often encountered by the users of the system, than would one based on model depth.

Conclusion

The refinement of habitat evaluation systems, and HEP in particular, has not been achieved. The concept of a habitat evaluation procedure is relatively new and receptive to improvements. Many critics of HEP are critics of the HSI models, correctly arguing that management decisions should not be based on a system that makes use of untested models.

The information behind model development is incomplete but offers the most accurate approach to habitat assessment for fish and wildlife. Habitat losses continue every day and a need for mitigation and compensation procedures exists now.

Model development and validation should be considered a top priority in refining the HEP methodology. Original models, with only species authority validation, should not be relied upon for habitat evaluation. Equations similar to those used in unvalidated HSI models were tried in this study and proved almost useless.

It is important to validate models over several sites. Because our equations were adjusted to fit the test data, the results are accurate only over those values. The models must be tested further on new sites to continue the refinement process.

Testing procedures used in this study are simple and direct and can be followed at a relatively low cost. They should be applicable in any situation, providing population data are available.

A major weakness of this study was the use of only one year's population data. Any model should be validated with at least two years' data. Population data may already exist with many fish and wildlife agencies, universities, and some private organizations. Surveys, censuses, and other studies have gathered population data for many species over different sites, and these may be used for model validation, assuming that one has the necessary habitat information recorded when the populations were sampled.

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Monitoring the Population Status of American Woodcock

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Introduction

The American Woodcock *(Scolopax minor)* is a popular gamebird throughout its range in eastern North America. Once regarded principally as a traditional quarry of a relatively small, specialized group of upland gunners, its importance as a recreational resource has grown in recent years, providing hunting opportunity for a much broader base of hunters. Interest in woodcock hunting has grown, particularly in southern states. Precise harvest estimates are not available, but in the United States the annual woodcock harvest probably exceeds 2-million. The woodcock remains an important gamebird in Canada where it comprises nearly half of the annual harvest of migratory gamebirds other than waterfowl (Wendt and Hyslop 1981). Woodcock also provide recreational opportunities for many people who enjoy observing their unique courtship displays each spring.

Fish and Wildlife Service responsibility for the conservation and management of woodcock in the United States is based on the 1916 *Convention for the Protection of Migratory Birds* between the U.S. and Great Britain (for Canada), and its implementing legislation, the Migratory Bird Treaty Act of 1918. The Treaty lists the woodcock as a migratory game bird. The Act directs the Secretary of the Interior to determine to what extent migratory game birds may be hunted and to adopt suitable hunting regulations. In fulfilling its legal mandates, the Service works closely with states and private conservation organizations that have a vested interest in woodcock. Conservation and management endeavors have been conducted under longstanding terms of mutual interest and understanding. Likewise, the Service has cooperated closely with the Canadian Wildlife Service on woodcock programs and problems of mutual concern.

Conserving and managing migratory birds to provide optimum opportunity for their use and enjoyment by people is an implicit goal in the legal mandates and an explicit goal of the Service's Wildlife Resources Program. This goal generally is reflected in specific population objectives expressed in terms of a desired population size at some time of the year. To assess the achievement of the population objectives, some system for monitoring population status is desirable. This is especially important for species such as the woodcock for which other extensive information regarding status is not available.

For woodcock, the annual Singing-Ground Survey provides the most significant information to guide range-wide management. In its present form, survey observers count singing males along permanent, randomly located routes in the woodcock's principal breeding range. The observers record the number heard at each of 10 stops along a 3.6 mile (5.8 km) route. The counts are timed to coincide with peaks in seasonal and daily courtship activities. In contrast to surveys that provide direct estimates of populations, the Singing-Ground Survey provides an *index* of the size of the spring population. The average number of woodcock heard singing per route, weighted for land area, is used as the index.

The need for information about woodcock abundance was recognized more than 40 years ago, long before quantitative ecologists, biometricians, and specialists in survey design were common among wildlife professionals. Consequently, today's singing ground survey is the product of a long evolutionary process rather than a single-step effort in survey design. This evolutionary process has resulted in a survey very similar to what might be expected from a more contemporary design effort in which diverse and important subjects such as management objectives, statistical validity, costs, practicality, and the bird itself are considered. Herein we trace the evolution of the singing ground survey from its beginnings in the late 1930s to the present state of the art. We attempt to show how each of the important considerations in survey design has been accommodated and how problems have been addressed over the years.

The Evolution of the Singing Ground Survey

The Approach

The Singing Ground Survey began in 1937 when Mendall, Swanson, and Aldous established a route at Moosehorn National Wildlife Refuge in Maine to obtain annual counts of singing woodcock (Mendall and Aldous 1943). Because woodcock are small, solitary, and cryptic, populations cannot be estimated by direct counts. Fortunately, though, male woodcock can be counted readily in the spring due to their unique and conspicuous courtship behavior. Thus, an audio-index was a logical approach to monitoring the status of the study population. Their choice of a road system as the sampling site was also logical and convenient. Woodcock seek open areas for singing grounds, and over major portions of their breeding range many of the openings used are associated with areas altered by human activities. Fields and clearcuts are examples. Such areas are commonly associated with road systems.

The use of audio-indices and road systems to monitor bird populations is widespread. Gamebirds such as pheasants and quail, and many nongame birds, are commonly censused in this manner. The literature on audio-indices is extensive and, for some species like the mourning dove *(Zenaida macroura),* large enough to constitute a sizeable bibliography (Stone 1966). Regardless of the species involved, virtually all surveys based on an audio-index obtained along a road system have certain inherent problems and attendant considerations that must be addressed. Terrain, observer ability, and environmental disturbance can affect counts. The bird's singing or calling rate can vary because of weather or time of day. Other biological considerations are also important, especially the relationship between the audio-index and the target population, i.e., the total number of woodcock present in the spring. Users of audio-indices have devised numerous ways of coping with factors that influence bird counts. Most have been deterministic attempts to reduce bias and variability through use of adjustment factors and stringent controls on sampling procedures. More sophisticated, stochastically oriented measures include the use of statistical models that can account for variation attributable to the factors that influence counts. For an excellent overview of contemporary uses of audio-indices and the approaches to solving associated problems, the reader is referred to Ralph and Scott (1981).

Coping with Sources of Bias and Variability

A sampling scheme for route selection was not an important consideration for Mendall et al. in 1937, because initially they were interested only in a local population of woodcock. However, as the potential applications of their work were realized, the desire for population data over a broader area developed. By 1948, scattered survey routes had been established over much of New England and eastern Canada. By 1952, permanent routes were established as far south as North Carolina and as far west as Minnesota. These early routes frequently were established at the discretion of a cooperator who had extensive knowledge of the local distribution of woodcock and a general interest in the survey. Thus, these first routes reflected the distribution of cooperators rather than woodcock, and in some states the routes were clumped around college towns. The number of routes in states varied greatly. For example, in 1952 there were 10 in Maine, 33 in Ontario, and 2 in Pennsylvania. These routes were usually located in prime habitat, and often they varied in length and number of listening points. Some routes were run more than once each year. Although this early work represented a positive initial effort, this haphazard approach complicated considerably the determination of population changes between years.

By 1952, it was apparent that any successful effort to monitor the status of woodcock populations over a large area would require consideration of several statistical and biological problems. With this in mind, Kozicky et al. (1954) carefully examined data collected during the period 1948–52, primarily to identify any discernable population trends and to develop a sampling plan to annually assess population change. They recommended that: (1) survey routes be selected randomly, (2) biases be identified and controlled or accounted for, and (3) routes be increased in number and sampled once annually. These recommendations addressed problem areas that fit quite neatly into the categories identified as sources of bias for bird counts presented by Verner (1981:391) some 27 years later.

Kozicky et al.'s (1954) recommendation that many routes sampled once was superior to few routes sampled more than once was soon incorporated into survey operations, but some years elapsed before the use of randomly located routes was explored. First, consideration was given to retaining the nonrandom routes and developing a co-index of habitat to be used as an adjustment factor in interpreting results (Aldrich 1954). No progress was made however, because the ephemeral and disjunct nature of woodcock habitat makes quantitative and qualitative assessments difficult. The situation persists today despite technological innovations such as satellite imagery. Finally, in 1962, the Service and the Michigan Department of Natural Resources initiated a study to determine the feasibility of using random routes (Martin 1964). One hundred twenty six routes were established randomly in lower Michigan and sampled for three years. A similar study was initiated in West Virginia in 1965. When results from concurrently run random and nonrandom routes were compared, it was concluded that counts from random routes were more representative of actual population densities and distribution and more accurately reflected changes in numbers of birds (Goudy and Martin 1966).

Conversion of the survey to random routes began in 1967. States and provinces were designated as sampling strata, and 10-minute blocks of latitude and longitude served as the primary sampling units. Detailed procedures were developed for selecting routes. Within strata, blocks were selected using a random start with qualified random selections thereafter. Within selected blocks, the intersection of secondary roads closest to the block center was used as the starting point for the route, which then proceeded in a randomly selected direction.

Conversion to random routes was largely completed by 1970. The resulting system of some 1,300 randomly located routes throughout the major portion of the woodcock's breeding range (Figure 1) provides the basis for the survey as presently conducted. The number of routes in each management region coincides closely to the number of routes determined by Kozicky et al. (1954) that would be required to detect a 5 percent change between consecutive years at the 5 percent probability level. Each route represents approximately 500 square miles (1,300 km^2). Routes

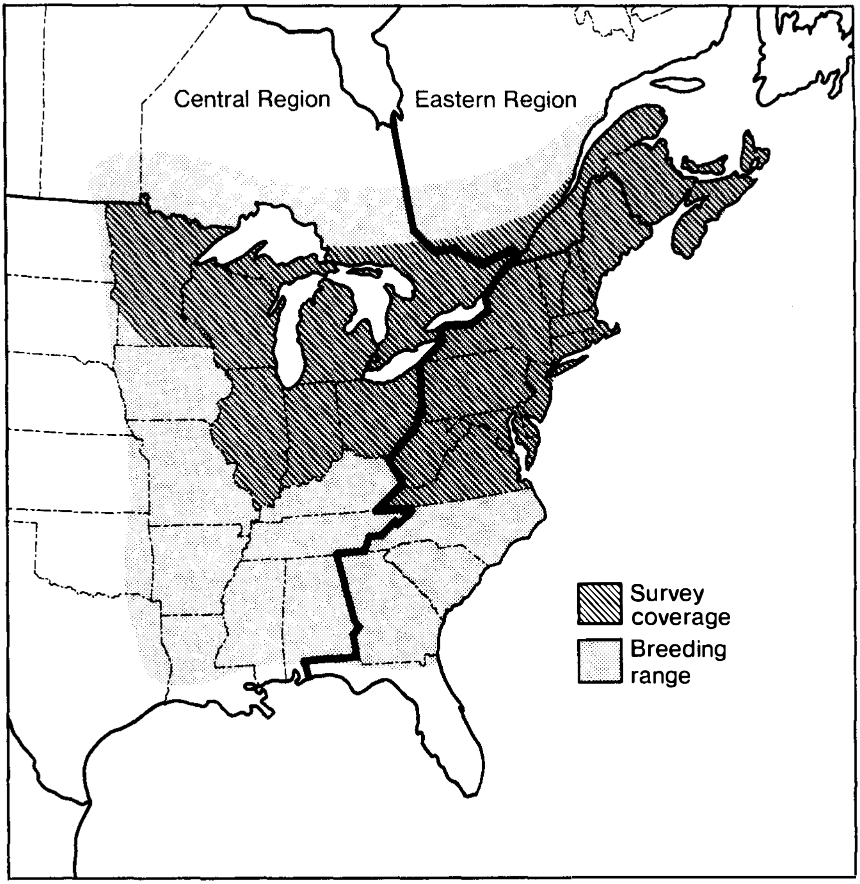

Figure 1. Singing ground survey coverage and woodcock management Regions.

were intended to be permanent and to be sampled once each year during the breeding season. Except for some that were replaced for various practical reasons, (e.g., road closure or reservoir construction) the same routes have been used each year since 1970.

It was anticipated that some randomly selected routes would fall into marginal habitat where woodcock would be counted infrequently or not at all. Consequently, when no woodcock are heard for two consecutive years, the route is not run for five years and it is carried as a constant (assumed) zero count for analytical purposes. Constant zero routes are scheduled for resurvey in the sixth year after being suspended from the survey. If woodcock are present, annual counts are resumed. If not, the route remains a constant zero. This procedure has the practical benefit of reducing survey costs, but it presents a problem, which is discussed in more detail later. Since breeding woodcock are present in low densities in many strata (i.e., a mean count of less than one bird per route), a substantial number of constant zero routes occur.

The potential biases in the survey have been addressed most notably in studies by Goudy (1960) and Duke (1966) who expanded on work done earlier by Sheldon (1953). All three authors studied such factors as scheduling (time of season and day), environmental conditions, and observer ability. Among other things, they determined periods of relative stability in seasonal and daily courtship activity, onset and duration of singing, and distance at which woodcock could be heard by an observer. They made several recommendations. Some important ones and the rationales behind them were:

1. Routes should be run during a three week period beginning April 10 in southern portions of survey regions and ending May 20 in the most northern portions. Sexual recrudescence occurs early in woodcock; males occasionally begin exhibiting courtship behavior on wintering areas and continue through migration. The recommended dates focus the survey period after most migrants have passed through an area, thus minimizing the possibility of counting transient males.
2. Counts should begin approximately 22 minutes after sunset (15 minutes if cloud cover exceeds 75 percent). Woodcock are rather punctual about beginning evening courtship performances, usually starting when light intensity is approximately 2 foot-candles, a condition generally occurring several or more minutes after sunset depending on cloud cover.
3. Counts should be made during a 30 to 35-minute period following the recommended starting time. Courtship performances last approximately 45 minutes, varying with the duration of twilight, which increases with latitude and advancing season. A properly timed 30 to 35-minute counting period falls nicely within the courtship period.
4. Counts at each stop along the route should last 2 minutes. Woodcock courtship performances alternate continuously between display flights lasting approximately 1 minute and singing on the ground. Thus, if a male is present and performing, it is highly likely that he will sing within any 2-minute listening period.
5. Stops should be spaced 0.4 miles (0.65 km) apart. The maximum range at which woodcock can be heard by observers is 0.2 miles (0.33 km). Thus, a stop interval of 0.4 miles prevents duplicate counts.

6. Counts should not be made during heavy rain, snow, high wind, or temperatures below 40°F (4°C). Normally, weather has little effect on courtship performances, but the conditions listed above result in curtailed activity.
7. Counts by new observers should not be included when determining the changes in the population index between consecutive years. Because observers may vary in their ability to hear a woodcock's song, it was judged that counts by different observers may not be comparable.

Although not specifically mentioned, an outgrowth of recommendations 3 and 5 was that routes consist of 10 counting stops. Allowing 2 minutes for listening at each stop and 1 to 2 minutes for travel between stops, 10 stops are appropriate to the recommended 30 to 35-minute counting period.

The potential effect of disturbance was noted in these studies but did not result in any specific recommendations. Some routes have considerable noise associated with them. Most often the source is traffic in populated areas and amphibians in rural areas. Clark (1970) later addressed the question of disturbance and concluded that eliminating counts from stops where disturbance was high did not significantly change results. He further surmised that the subjectivity involved in evaluating or quantifying disturbance on routes may introduce its own form of bias. Thus, no attempt has been made to account or correct for disturbance. It is simply considered to be a random component of sampling error.

The above recommendations were gradually implemented, and by 1968 procedures for counting woodcock had become fully standardized: counts lasting 2 minutes were to be made at each of 10 stops on a randomly located, permanent route; routes were to be run during optimal periods of seasonal and daily courtship activity under favorable environmental conditions; data from routes not run within acceptable limits were to be eliminated from analyses. Although seemingly stringent, these procedures effectively accommodated the potential sources of bias and variation considered above. These procedures have remained in effect to date.

Developing Analytical Procedures

Procedures for analyzing woodcock count data and for calculating population indices evolved parallel and subsequent to developments in sampling design and counting procedures. For Mendall and Aldous (1943), the population index was simply the total number of birds heard. However, as the survey developed it became necessary to modify continually and expand analytical procedures to accommodate changes. As might be expected, the early development of analytical procedures was as haphazard as the evolution of other aspects of the survey. Evidence of this can be seen in the statistic used as the population index, which, at various times during early years, was total birds heard on routes, birds per route, birds per stop, and birds per stop per run. Details of these early procedures can be found in a series of USFWS Special Scientific Reports beginning with Williams (1950). In this paper we describe only the analytical procedure that eventually evolved as being compatible with the sampling design and counting procedures employed in the late 1960s.

Central to the analytical procedure was the exclusive use of "comparable" (i.e., paired) data to calculate a change in the population index between consecutive years. Data were considered comparable if the route was run in both years of comparison by the same observer under similar and acceptable conditions. Using only comparable data, population indices (mean numbers of singing males per route) were calculated for each stratum (state). Stratum means were weighted geographically to calculate regional and continental means. Because counts from the same pairs of routes are not necessarily comparable from year to year, this procedure required that two means be calculated for each year: one comparable to the mean of the preceding year and one comparable to the mean of the next year.

This procedure satisfactorily allowed the calculation of population changes between consecutive years, but it complicated the assessment of trends among years, because no single index could be quoted for a given year. Beginning in the mid-1960s, these long-term trends were emphasized much more than they had been in the past. To achieve a meaningful comparison among groups of years, a base index value was arbitrarily chosen as a starting point, and this value was adjusted by the proportional changes between consecutive years (Clark 1970).

Interpretation of the Population Index

By the end of the 1960s the Singing Ground Survey had evolved to a point where sampling design, operational procedures, and analyses were all standardized and apparently quite acceptable for obtaining annual population indices and long term trends. During the 1970s the survey was unchanged. Research efforts focused on the important, fundamental question: what does a singing male represent in terms of general woodcock populations. This area of study, although important to a thorough understanding of woodcock breeding biology, poses very difficult problems for field study. The question consists of two issues: what is the numerical relationship between singing males and the number of females present, and what is the numerical relationship between singing males and nonsinging (subordinate) males which exist in the population.

These problems were addressed in at least four studies. Unfortunately, the results of these studies were largely inconclusive and in some respects contradictory. Godfrey (1975) studied a population of woodcock at the Cloquet Forest in Minnesota. He concluded that singing ground counts could be representative only if they were adjusted for numbers of nonsinging males. The method recommended in his study to account for the bias introduced by the presence of nonsinging males would be impractical to implement. Additionally, it was not clear how an independent population estimate was obtained. No recommendations resulting from his study were adopted. Whitcomb (1974) and Bourgeois (1976) in related projects studied an insular population of woodcock on High Island in Lake Michigan. They concluded that counts of singing males represented the actual population of males on the island quite well (Whitcomb and Bourgeois 1975). However, their method for obtaining the independent population estimate was somewhat tenuous. Gregg (1982) studied a population in Wisconsin and concluded that a close relationship existed between numbers of singing males and nesting females. Couture and Bourgeois (1978), in a study in central Quebec, concluded the opposite, but their results likely are not definitive because they worked with an estimated average population of only four males. Dwyer (in prep.) has taken the best approach to date. He studied a heavily banded population at Moosehorn National Wildlife

Refuge in Maine for five years and used the methods of Darroch (1958), Jolly (1965), and Otis et al. (1978) to obtain independent estimates of the population. Dwyer concluded that although counts of singing males were not highly correlated with the independent estimates, they generally reflected the population trend.

We feel that the actual numerical relationships are of interest but not critical to our informational needs at this time. We are willing to assume, for the present at least, that whatever the relationships are, they have evolved over a long period of time and can be considered as constant. Annual indices are biased in some degree to the extent that this assumption is violated, but in our judgment it does not compromise the results seriously.

A Contemporary Evaluation of the Singing Ground Survey

Survey Procedures and the Test of Time

The period of unchanged survey procedures that existed during the 1970s afforded an opportunity to observe the standardized Singing Ground Survey in operation. Field procedures appear to have been, and continue to be, sound and practical, and for the most part have yielded satisfactory results. Coordination of the survey has worked smoothly at state, regional, national, and international levels. The survey has proved to be economical, requiring in our estimation, about 3 person hours and $15.00 in expenses to run each route. On the other hand, it was recognized by the late 1970s that problems existed with the analytical procedures that had been used to assess annual indices and trends for woodcock, and with similar surveys conducted for mourning doves and several species of nongame birds. Consequently, the Service took steps to evaluate analytical methods with the objective of providing a better depiction of population change. The problems were caused primarily by the restrictive practice of using comparable data for determining population changes between years, the use of the base year adjustment to show trends, and the inclusion of many low-density routes as constant (assumed) zero counts. Tautin (1982a) discussed these problems in greater detail and pointed out that approximately 25 percent of the data collected each year are not used because of problems with comparability. Geissler and Dolton (in prep.) discuss similar problems with base year adjustments for mourning dove survey data. We propose three new approaches to these problems, which are intended to provide an improved analysis of Singing Ground Survey data.

Estimating the Annual Population Index

Changing observers between years has always been the most frequent cause for considering data not comparable, and therefore not useable for estimating annual means. To a lesser extent, failure of observers to adhere strictly to recommended starting times and duration for counts also has been a cause for rejection of data. The loss of this otherwise potentially useful information has not resulted in increased estimated variance, but the use of comparable data and the attendant base year adjustment cause conceptual and other problems (Geissler and Dolton, in prep.). Tautin (1982a) questioned the necessity of using only comparable data. He tested differences in counts made by new versus the same observers and concluded that, although differences exist between individuals, they are largely compensatory at regional and continental levels of analysis. He also suggested that, although recommendations for survey procedures were sound, criteria for accepting field data were too severe.

It thus appears that abandoning the use of comparable counts in favor of using all counts would be preferable for calculating an annual index and would be conceptually simple. The procedure would be to substitute the mean route count for routes not sampled, weight by the geographic area represented by the route, and calculate means at state, regional, and continental levels. Unless some definitive, contrary indication is noted in the near future regarding observer difference, we would propose that data from so-called noncomparable routes be included in subsequent analysis of woodcock survey information.

Estimating Trend

We propose using the new route regression method that was developed by Geissler for determining long term population trends. It is now being used to analyze data from the Breeding Bird Survey, a cooperative project coordinated by the Service to assess nongame bird populations (Robbins et al., in prep.). The method's early development was reported by Geissler and Noon (1981), and the current version of the method is being reported by Geissler and Dolton (in prep.). They propose using this method for the mourning dove Call-Count Survey.

In the new method, the rate of change in counts along each route is estimated using a simple regression model:

$$c_{jky} = b_{jko} b_{jk} e_{jky}$$

where c_{jky} = count in year y on route k in state (stratum) j

b_{jko} = intercept on route k in state j

b_{jk} = call-count trend on route k in state j

e_{jky} = random error term associated with the predicted count. The error terms are assumed to be lognormally distributed with mean = 0 and variance = S^2.

Counts are log transformed after adding an arbitrary positive value of 0.5 to c_{jky} because the log of a zero count cannot be taken. Estimates of b_{jk} can then be obtained using linear regression taking logarithms of both sides of equation 1. Note that covariables for the effects of observers, weather conditions, or disturbance could easily be incorporated into the model. Consecutive counts are not required for a regression. Thus the method effectively handles the case of missing observations, including cases in which routes have not been run for five years as is done under the constant zero regime, without substitution.

State, regional, and continental estimates are obtained by summation. For example, the regional estimate is:

$$b' = (\Sigma\Sigma\, b'_{jk}\bar{\bar{c}}_{jk} w_{jk} N_j/n_j)/(\Sigma\Sigma\, \bar{\bar{c}}_{jk} w_{jk} N_j/n_j)$$

where N_j = area of the jth state,

b'_{jk} = estimate of slope (trend on logarithmic scale on the kth route of state j)

n_j = number of routes in the sample from jth state which provide estimates of b_{jk},

$\bar{\bar{c}}_{jk} = \left[\prod_{y}^{p} (c_{jky} + 0.5)\right]^{1/p} - 0.5$ geometric mean of singing ground counts on kth route in jth state (0.5 added to avoid multiplying by a zero count),

w_{jk} = weight to account for differences in the variances of route trend estimates. w_{jk} is selected so that $v(b_{jk}) = w - l_{jk}S^2$.

Note that these functions combine the route trend estimates, b_{jk}, weighting by: (1) area of the state, N_j, assuring that equal areas receive equal weight if other factors are equal; (2) geometric mean of the counts on the route, c_{jk}, giving more weight to trends in areas with high populations, which have greater impact on the trend of the total population; and (3) weight, w_{jk}, which stabilizes the variances of the route trend estimates and reduces the variances of the trend estimates for states, management units, and the continent (see Geissler and Noon 1981 and Geissler and Dolton, in prep. for the development of these estimators). Note that the product of weighting factors for land area and population density yields a weighting factor that is proportional to the estimated woodcock population sampled by that route. These weights were derived so that we estimate the rate of change in the management unit population over time.

The jackknife (Cochran 1977:178–180) is used to estimate the variances of the trend estimates. It correctly calculates the variance among groups of routes, slightly overestimating the mean square error of a ratio, as compared to the substantial negative bias of the usual variance estimator.

All tests are performed on the logarithmic scale. The estimates and the end points of the confidence intervals are back transformed using the relationship

$$b = \exp[b - 0.5v(b)].$$

To compensate for the bias inherent in the logarithmic transformation, the expected value of the lognormal distribution is $\exp(\mu + 0.5\sigma^2)$. These values are expressed on a percent change per year $[(b - 1)100]$ to make them more easily understood.

Constant Zero Routes

The constant zero problem stems from the fact that woodcock exist in relatively low densities (2.75 is the approximate long-term average count per route) and many zero counts are recorded each year. The probability of two consecutive zero counts is high, and thus the probability that a route's count will be assumed zero for five years, is also high. Indeed, about 35 percent of all routes have been in this category at some time. Carrying a route as an assumed zero when in fact birds may exist at very low densities (a mean of less than 1.0 per route) could introduce spurious results in the annual index and long term trend. Stokes (unpublished report, files USFWS, Laurel, Md.) studied the problem and developed a mathematical model using assumed count means and a clumping parameter based on the negative binomial distribution. She determined that, theoretically, predicted annual means of counts would decrease the first several years of a survey due to carrying some routes as assumed zeros and that the decreases would diminish over time, with the predicted means of counts stabilizing at a level below the actual means. To determine the magnitude of this theoretical effect, we created a simulation model using realistic input and generating an artificial data set on the scale of our actual data set (15 years of counts from approximately 1,300 routes). We compared results between analyses in which a constant zero regime was imposed and one where it was not. The constant zero regime eventually reduced estimated annual means by about 8 percent and introduced a spurious decreasing trend of about 2 percent per year over the first several years of the simulation. These figures are cause for concern, indicating that carrying counts as assumed zeros can lead to erroneous inferences of population trend. Fortunately, the solution appears rather simple. Simulation modeling suggests that for calculating annual means, assuming the route's mean count instead of zero is appropriate. For determining trend, nothing needs to be done because the trend model proposed above handles the case of missing observations quite nicely.

Expected Results

Since our proposals for new analytical procedures are preliminary, we are hesitant at this time to present results that might be construed as final. However, it appears that our proposed method for estimating annual indices (means) will yield estimates on the order of 2.65 (s.e. = 0.14) birds per route for the Eastern Region and 2.82 (s.e. = 0.16) for the Central Region. The route regression model proposed for estimating trends (unadjusted by covariables) indicates a decreasing trend of 2.4 (s.e. = 0.48) percent per year in the Eastern Region and an increase of 1.6 (s.e. = 0.42) in the Central Region. The annual and trend estimates reported here compare favorably to those obtained formerly using comparable data and the base year adjustment (Tautin 1982b), and suggest that these earlier methods produced reasonable estimates despite their inherent problems.

Summary

Singing-ground surveys to monitor woodcock populations were initiated in 1937, a time when wildlife biology as a science was in its infancy. The fact that early workers moved quickly to expand the survey program and carefully documented the significant problems (identified as biases in more recent terminology) stands as a credit to their wisdom and ingenuity. Basic survey designs recommended some 29 years ago remain sound when subjected to criteria employing modern concepts of statistical design. Major sources of bias that result from scheduling and environmental conditions have been carefully evaluated and are now satisfactorily controlled.

The development of appropriate analytical techniques, although lagging behind the control of data collection, has evolved in an orderly fashion. The most significant aspect of this recent evaluation of analytical techniques is that the results do not differ markedly from those presented in the most recent past.

Does the Singing-Ground Survey provide information useful for management purposes? We believe it does and that our proposed new analytical methods will enhance its capabilities. Although the studies of the 1970s (see above) did not conclusively answer the question, certain empirical information suggests that the answer is affirmative. The blizzard that struck the Northeast in early April, 1982, was predicted to impact adversely on woodcock that had already returned to their breeding grounds. Subsequent results from the singing ground survey showed a decrease of 20.3 percent from 1981, suggesting that the survey is sensitive to between year population changes. The change was the largest recorded in the 15-year history of the randomized survey (Tautin 1982b). It prompted the Service to propose a regulatory restriction directed at reducing harvests during the 1982 hunting season. The indicated long term population decline in the Eastern Region has been steady, the result of annual changes of low absolute value, suggesting a slow and insidious cause. The loss in quality and quantity of habitat has been suggested as the primary cause of the population decline. Coulter and Baird (1982) and Dwyer et al. (in press) present substantiating information. The probable connection between population decline and habitat loss presently serves as the focal point for the development of national and regional management plans.

Our proposed changes in analytical procedures will make the Singing-Ground Survey current with the state of the art in bird surveys. We have no reason, however, to expect that the evolutionary process is complete. Changes will continue to be made as necessary to keep the survey properly tuned, and perhaps some work will be done to develop a link between the spring breeding population index and fall populations. For now, though, we conclude that the Singing Ground Survey provides a practical, economical, and satisfactory means of monitoring woodcock populations on a broad scale. It thus serves an important role in contemporary migratory bird management.

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Emerging Nonfederal Initiatives in Resource Management

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Introduction

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In the last decade or two, the federal role in managing wildlife and other resources continually expanded—an outcome generally welcomed by other governmental levels and by the private sector. Recent proceedings of the North American Wildlife and Natural Resources Conference have reflected this trend by devoting significant attention to exclusively or primarily federal programs.

Something new is happening, however. In the last few years, we have seen unprecedented fluctuations in federal funding, personnel, and leadership in the natural resources field. This situation gives new significance to the growing number of conservation activities that take place exclusively or primarily at the state and local level, or among businesses and nonprofit groups. For example, it may be that some traditionally federal tasks could be conducted more effectively elsewhere, just as in other cases, a nonfederal approach might be a poor substitute for federal action. And in an era when nonfederal management is expanding while the federal profile is lessening, opportunities for making these respective efforts complementary are obviously of increased importance.

In the early decades of the American Game Conference and the North American Wildlife and Natural Resources Conference, when the federal role in wildlife management was minimal, our proceedings were often dominated by discussions of nonfederal resource management. It is time for another close look at such approaches. The papers presented here show in unprecedented detail what a remarkable variety of management activities is now being carried out below the federal level. The two discussants have made the additional contribution of placing this subject in a broad perspective. The organizers of this session hope that these nine contributions will help clarify future options in managing wildlife and other resources.

State Wildlife Revenue Sources and Commitments, Alabama, Missouri and Washington

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State wildlife conservation agencies vary in their organizational structure, responsibilities, objectives, and operations. Generally, they are not supported by general fund monies but instead receive the bulk of their revenue from the sale of licenses, fees, permits, fines, and federal aid under the excise tax provisions of the Pittman-Robertson and Dingell-Johnson programs. The objective of this paper is to examine three state wildlife agencies that vary in funding levels. Specifically, this paper will review (1) agency objectives, (2) fund sources, (3) budget limitations, and (4) agency function.

Alabama

Alabama is a deep south agricultural state. It is the 29th state in size with 32,690,000 acres (13,239,450 ha) of land. The terrain ranges from semi-tropical Gulf Coast to rolling prairie to mountains in northern Alabama. The highest point is 2,407 feet (734 m) above sea level. Alabama is well blessed with an extensive river and lake system composed of 1,200 miles (1,931 km) of navigable waterways and almost 600,000 acres (243,000 ha) of impoundments. Major river systems include the Tennessee, Coosa, Alabama, Tombigbee, Chattahoochee, and Warrior.

The climate in Alabama can be quite warm and humid in summer. The average yearly temperature is 65.8° F (18.8° C) and average annual rainfall is 53.3 inches (135.4 cm). Combined with a long growing season of 190 days in the north to 298 days annually in the south, this makes Alabama ideal for productive agriculture, the state's number one business. In 1974, soybeans finally replaced cotton as the top cash crop.

The second most important industry in Alabama is forestry. Alabama forests cover 22,000,000 acres (8,910,000 ha), more than two-thirds of the state. These forests currently are growing 40 percent more wood than is being used. There are numerous oak-hickory forests, but the vast majority of the forests is in pines.

The 1980 population was 3,863,698 citizens. Birmingham is the largest city with 832,387 residents in the metropolitan area. Other major cities and their 1980 populations are Mobile (199,392), Montgomery (176,781), and Huntsville (142,238).

Agency Objectives, Organization, and Operations

The agency charged with the protection of the wildlife resources in Alabama is the Game and Fish Division of the Alabama Department of Conservation and Natural Resources. The stated goals of this division are "to protect, enhance, and provide utilization of Alabama's wildlife resources to meet the present and future demands for consumptive and nonconsumptive purposes."

The Department is headed by a commissioner appointed by the Governor. It is divided into five operational divisions, a Support Services Division, and staff sections. The five operational divisions are the Marine Police, State Lands, State Parks, Game and Fish, and Marine Resources. Originally there was a Forestry Division but this was changed in the early 1970s when the legislature created a separate Forestry Commission.

The Game and Fish Division consists of three line sections operating directly under the administrative section headed by a merit system director and assistant director. The three sections are Fisheries, Wildlife, and Law Enforcement. All personnel in this division are state merit system employees. This system has proven extremely stable. While the commissioner of the Department is normally replaced by a new Governor every four years, Alabama's present merit system director has served 23 years in this position. This has allowed the Division to maintain a steady movement towards the goals of enhancing wildlife populations without the frequent and often counter-productive changes of direction common to more politically oriented wildlife commissions or agencies.

Funding Sources, Constraints, Commitments, and Trends

The Game and Fish Division is relatively unique among Alabama's state agencies. It receives no state general fund revenue and must operate within the income generated by licenses and permit sales, federal aid to wildlife and fisheries funds, and fines.

Even though the Division is self supporting, the operating budget must be approved by the legislature. Originally there was no constitutional guarantee to prevent Game and Fish funds from being used by the legislature for non Game and Fish projects. In 1967, the Division successful in getting a constitutional amendment passed by the voters to protect Game and Fish funds and to insure they would only be used for approved projects that were wildlife related.

Hunting and fishing licenses and permits revenues usually account for approximately 71 percent of the Division's income. Other sources of revenue and their approximate percentages of the total Game and Fish Division budget are Dingell-Johnson federal aid to fisheries (6%), Pittman-Robertson federal aid to wildlife (17%), fines (4%), and miscellaneous such as rentals and timber sales (2%). This heavy dependence upon license revenues means that the Game and Fish Division must continue to seek license fee increases in an effort to maintain the same program level. Because of the high inflation rate and increased employee benefits, the Division is unable to keep the same level of operating funds available for ongoing programs.

All hunting and fishing license fee increases must be approved by the state legislature and the Governor. This means that funding usually increases only after it has become obvious to state legislators that the Division's financial condition has reached the critical level and programs are being reduced. Because of the inability of the traditional revenue sources to keep up with inflation or to allow the Division to respond to new or additional responsibilities, attempts have been made to find new sources of revenue. Most of these will probably result in little additional revenue but follow the philosophy of the user paying. For example, in 1982 the Fisheries Section implemented a program of charging pond owners for the cost of fish to stock new or renovated farm ponds. Due to continued streamlining of hatchery culture and delivery operations, the present cost is only $30/surface acre to deliver fingerling bass and bream for pond stocking to localized delivery points within Alabama. Since pond owners are not obligated to allow public fishing, it is felt they should pay the cost for these fish. This resource is important since surveys have shown that approximately 20 percent of the fishing trips by licensed fishermen in Alabama are to farm ponds. However, since only about 2,000 acres (810 ha) of new or renovated ponds are stocked in Alabama each year, this is expected to result in approximately $60,000 additional revenue annually.

The legislature passed a state migratory waterfowl stamp law in 1979. This stamp only brings in about $60,000 each year, one-half which is spent out-of-state. This amount is totally inadequate to fund a truly meaningful program for waterfowl.

The 1982 legislature did pass two bills that are expected to eventually improve the Division's funding base. One is the nongame wildlife state income tax refund checkoff. This allows individuals who are to receive a state income tax refund the opportunity to contribute directly to Alabama's nongame wildlife program. This contribution is tax deductible in the following year. It is unknown how much revenue will be derived from this source, but the potential has been proven in several other states. Unfortunately, the legislature did not provide any funds to promote the program, and this is causing the first year's funding to come out of the already strained Game and Fish program and from donations.

The other bill is the lifetime hunting and fishing license program. Our agency can now sell a lifetime license costing $100 for fishing, $200 for hunting, or $300 for the combination. This money is invested in a special endowment fund and only the interest can be used. The present resident annual license cost is $6 for fishing and $10 for hunting. At the present rate on investment, it is expected that the return each year will be greater than the license revenue received from an individual license buyer. This fund should continue to grow and help offset the loss of purchasing power brought on by inflation as long as investment returns remain high.

Budget Limitations

The major effects of budget limitations are reduction of personnel, usually by attrition and the reduction of program levels. As employee benefits and salaries increase at a rate greater than income increases, it has been necessary to leave vacancies unfilled. Unfortunately, legislators often are unwilling to vote for a license fee increase unless assured that their district will be fully staffed with law enforcement or other specified personnel they feel are needed. This means that legislative license fee increases often bring with them costs that may partially offset the increased income. When an employee is hired, especially in a new position, it usually represents a long-term funding commitment at an ever increasing level.

The end result, for an agency operating on license revenue as Alabama's Game and Fish Division does, can be a long-term loss of operating funds. Prior to the last license increase in 1979, revenue was increasing only 0.8 percent per year. Employee salaries and benefits were consuming 73.5 percent of the total income, leaving only 26.5 percent for equipment and operations. The license fee increase resulted in a 40 percent income increase the first year, and employee benefits and salaries decreased to 62.4 percent of the budget. Three years later, employee benefits and salaries were at 68 percent and climbing steadily, even with several vacancies remaining unfilled. At this level of increasing funding commitment for salaries and employee benefits, it is obvious that one of the following must soon occur:

1. The staff will have to be reduced further, either by attrition or reduction in force;
2. Funding for operations will be reduced to an ineffective level;
3. An all-out campaign must be made to convince the legislature and the Governor that another license increase is needed; or
4. New sources of revenue must be tapped.

Actually, all of the above are happening to some extent now in Alabama. An 11 percent salary increase was granted effective 1 October 1982 by the state legislature. Our law enforcement personnel received an additional 7.5 percent increase. Because the funding base has not increased, it has already become necessary to reduce personnel and operations at every level. Planned or needed staff expansions have been halted.

The new income sources are now starting to be tapped; however, some of these bring with them additional commitments, and others will not provide significant amounts of revenue. The need for an overall license fee increase is already being brought to the attention of many key sportsmen and conservation groups in the state. This continual dependence upon the legislature and license revenue certainly does not represent an adequate method of funding a wildlife program during times of high inflation.

Current Agency Function

With a total budget (FY 82–83) of $11.5 million, Alabama is probably one of the poorer funded game and fish agencies. Of this total, 68 percent, or $7.8 million, goes for salaries and employee benefits. Because yearly operating costs necessarily require a large percentage (30%) of the remaining funds, this leaves little (2%) that can be set aside for land acquisition or capital development projects. As a result of being heavily dependent upon license revenue, Alabama has not been able to acquire large tracts of land for wildlife management purposes.

The main thrust of the Game and Fish wildlife management program in Alabama has generally been: initial restocking of areas with low or depleted deer and turkey populations followed by protection and landowner encouragement to protect the stocked game and reproduction until huntable populations are established. While funds have been relatively low, Alabama's program success has been high. At one time, there were few deer and turkey left in Alabama. Now, all 67 counties in the state have a deer hunting season, and all but 6 counties have a turkey hunting season. Alabama has one of the most liberal deer seasons in the nation with a basic gun season extending from 19 November to 31 January in most areas. The limit for gun hunters is one antlered deer per day except during the either sex season when the limit is one antlered and one unantlered deer per day. The archery season in most areas opens on 15 October and extends through the end of gun season. The archery limit is one deer (either sex) per day. This means that most of Alabama has a 109-day deer season. In addition, the turkey limit is six gobblers per season.

In comparison to other states, Alabama is number one in the nation in the harvest of Eastern wild turkey gobblers and near the top in the number of white-tailed deer harvested annually.

Washington

Washington, the most northwestern of the "lower 48" states, is divided by the Cascade Mountains into two distinctly different regions. The western portion, heavily influenced by the westerly winds off the Pacific Ocean, is a land of heavy precipitation and mild temperatures. Western Washington is predominantly green, with thick forests of Douglas-fir, hemlock, and alder covering a high percentage of the land area. Eastern Washington, on the other hand, is cut off from the moist ocean air by the Cascades. Consequently, it is arid, with ponderosa and white pine in the high country and sagebrush the chief form of native vegetation in the lowlands. Irrigation, however, has turned much of the once-unusable east side into a productive agricultural area where wheat, apples, and other crops abound.

Although the smallest of the 11 western states, Washington is second only to California in population among those states, with just over 4-million residents. Over 75 percent live west of the Cascades, with 60 percent in a 5-county area bordering Puget Sound. About 56 percent of Washington's residents live in incorporated cities and towns, many of them in the large cities of the Puget Sound area. Four of the state's five largest cities—Seattle, Tacoma, Everett, and Bellevue—are in this area. The state's second largest city, Spokane, is near the extreme eastern end of the state.

Department History, Organization, and Responsibilities

The Washington State Game Department came into being in 1933, established by the Washington State Legislature as directed by an initiative of the people that passed in 1932. The initiative also provided for the establishment of a State Game Commission, a six member policy and rule-making body appointed by the Governor. Three commissioners must be from the east side of the state, three from the west.

The commission sets regulations and policies and appoints the game director, who heads the Game Department and is answerable directly to the commission. There is a deputy director and an executive assistant who serve directly under the director and three assistant directors, one for field operations, one for staff operations, and one in charge of financial and support services. Six division chiefs are accountable for specific areas of program responsibility. Fisheries management, habitat management, wildlife enforcement, and wildlife management are classified as the four "management divisions," while the engineering/lands and administrative divisions are classified as the department's "support divisions." For departmental management purposes, the state is divided into six regions, with a regional manager and staff for each. Regional offices are in Spokane, Ephrata, Yakima, Seattle, Vancouver, and Aberdeen. The department's main office is in the capital city of Olympia.

The Game Department is mandated to preserve, protect, and perpetuate the wildlife of the State of Washington, while maximizing public recreational opportunities. Its management authority extends to "all species of the animal kingdom which exist in a wild state," including those species classified as game species, furbearing animals, predatory birds, protected wildlife, and endangered wildlife. Specifically excluded from the department's management authority are fish, shellfish, and marine invertebrates classified as food fish by the Department of Fisheries, another of Washington's resource agencies.

Funding and Operations

Unlike other Washington State agencies, the Game Department is not funded from the state's general fund. Hunters, anglers, trappers, fishing guides, and other "consumptive" users of the wildlife resources provide about 58 percent of the department's funding with their purchases of licenses, stamps, punchcards, and permits. Federal funds, primarily Pittman-Robertson and Dingell-Johnson, provide another 38 percent of the department's operating budget, with about 4 percent coming from other sources, such as mitigation funds and private donations.

Nongame species of wildlife have attracted a steadily increasing interest over the past 20 years, and in 1971 the Game Department submitted a formal budget request that included funding for a nongame wildlife program from the state's general fund. Although the program was well supported, the legislature was reluctant to allocate money for it. Finally, the sale of personalized license plates was chosen as a preferred solution. Sales of personalized license plates began in January of 1974, with proceeds to be used to pay for management of the approximately 536 nongame birds, mammals, reptiles, amphibians, fishes, and certain freshwater invertebrates of Washington.

The fact remained, however, that the sale of licenses and permits provided a bulk of the department's operating funds, for everything from fish planting to creel census, pheasant rearing to mountain goat tagging, hatchery construction and land acquisition to enforcement of the trapping regulations. At the same time, the department was taking on new tasks and responsibilities as a result of such legislation as the Forest Practices Act, the State Environmental Policy Act, and other needed habitat protection measures without any extra money allotted to carry them out. Such programs are costing the agency about $800,000 a year.

As early as 1971 there were indications that revenues from license sales weren't keeping pace with increased operating expenses, but it was by no means a serious problem at that time. By 1975 the situation had become more significant, so the department asked for, and received, an across-the-board fee increase of $1.00 on all licenses. It was almost immediately apparent that the increase was too little, too late, and by 1977 the department was beginning to feel a real financial pinch.

In 1979, for the first time ever, the Game Department went to the legislature to request help—$6.3 million worth of help—from the general fund to bolster its enforcement and environmental programs, but the attempt failed.

Through its more than 900 vendors around the state, the department sells about

1.4-million licenses, tags, and permits each year, and those license sales currently generate about $14 million annually. Historically, license sales have grown about 7 percent a year, helping to offset inflation, but in the late seventies and early eighties, the figures for both licenses sold and subsequent revenues dropped. At a time when more money was needed, less was coming in. Inflation had quadrupled fuel costs, doubled paper costs, tripled the cost of a patrol vehicle, and increased personnel costs to meet the soaring wage-price spiral, and the Game Department was experiencing a drop in revenues.

When the 1981–83 Game Department budget was prepared, it was based on an analysis of the agency's projected needs for that period. The Governor's Office of Financial Management, meanwhile, prepared computerized projections of expected department revenue for those years. The two figures not only weren't in the same ballpark, they weren't even in the same league, and it became painfully clear that even the current level of operations would have to be scaled down. Cutbacks would be necessary even if the legislature approved a substantial license fee increase.

The legislators did grant a fee increase averaging 30 percent, the biggest increase sportsmen could reasonably be expected to accept. Because of some anticipated buyer resistance, the actual increase hasn't amounted to a full 30 percent.

A $50 million budget was approved for the department for the 1981–83 biennium, and, while this was about $5 million short of the budget requested, it was close to the actual revenue projections. Even though the Game Department has its own source of "dedicated funds," it cannot, by law, spend more than is appropriated by the legislature for any given period.

With the budget figure they were given and low revenue projections, department administrators decided that $5.2 million had to be cut from current programs. It made better sense, they reasoned, to make the cuts in 1981 rather than wait until the Game Fund balance had shrunk to a critical state.

It should be noted that the general economic picture in the country in general, and Washington State in particular, has also played a part in the current financial situation facing the Washington State Game Department. The whole problem isn't simply a matter of license revenues not keeping up with operating expenses. Three years ago, for example, the department employed about 100 people through the federally-funded CETA program. Those people were working in all of the department's six divisions and in all six of the management regions. Those people are all gone now, as a result of federal cutbacks.

On the state level, the lumber/logging industry has always been one of Washington's major employers, and the housing crunch has brought logging and mill activities to a virtual standstill. Tourism is also important to the Evergreen State, and the tourist business is down seriously. The commercial fishing industry is also big, and it has serious problems. Add them all up and it's obvious that a lot of Washingtonians are out of work and a lot of businesses, big and small, related to these major industries are closed down. The final result, of course, is an ever-shrinking tax base to operate all state agencies. State hiring freezes and programmed delays in paychecks for state employees have been among the results.

What It All Means

According to the National Wildlife Federation, about 20 of the 50 state fish and game agencies don't have sufficient funding to keep their programs running well, and the Washington State Game Department is one of those agencies. Because of its financial problems, both before and since the establishment of the 1981–83 budget, most fish and wildlife programs have not grown to keep pace with increasing needs, while other projects and programs have been reduced or totally eliminated. A number of agency positions have been eliminated in the past couple of years. Here are some examples of what goes on in a fish and game agency that doesn't have adequate funding.

In 1950, the Washington Game Department had 85 wildlife enforcement agents, the people who are the first line contacts with the general public. In 1982, there are 88, an increase of only 3 during a 30-year period when the state population has increased over 70 percent. The average manpower capability for eight western states is one agent/75,000 man-days of hunting and fishing. In Washington, the present ratio is one agent/230,000 man-days.

The Department's game farm program has been severely reduced in the past two years. Three of Washington's eight game farms have been closed completely, and production of birds, primarily pheasants, has been reduced by 50 percent.

A steelhead rearing pond facility has been closed and three major trout hatcheries have cut back operations to the point that 1-million fewer trout are produced each year in a state where steel-heading and lowland-lake trout fishing are extremely popular.

Two of the agency's three district offices have been closed, as have two habitat management area (HMA) offices. Habitat management areas provide about 800,000 acres (324,000 ha) of public land where both consumptive and non-consumptive wildlife enthusiasts can pursue their outdoor interests. All summer help for the state's 20 managed HMA's has also been eliminated.

The Game Department's engineering and construction budget was cut by about $2.25 million for 1981–83. With little money for expansion of facilities or for doing major repair work, there was little justification for keeping full crews in these areas.

The above cutbacks are but a few of the more obvious results of the Game Department's funding problems, but other, more subtle factors must be considered as well. For example, employee morale has suffered. Many employees, some of them dedicated professionals, are frustrated from trying to carry out important work and necessary programs without enough money or manpower. Money, directly or indirectly, is a reason why a number of long-time employees have left the agency.

In the meantime, old equipment isn't being replaced, department vehicles continue to roll up the miles, hatcheries and other facilities are showing the strain of old age, land acquisition is at a near standstill, fewer fish are being planted, and all the while, an ever-growing Washington population clamors for more and better services from the Game Department.

What's Ahead?

It isn't realistic to expect the sale of hunting and fishing licenses to take a sudden jump and turn the department's financial situation around overnight. By the same token, license buyers probably wouldn't tolerate another major license fee increase after shelling out 30 percent more in 1981. So, how are things looking for the near future of the Washington Game Department?

The chances of the department's getting relief from the state's general fund are at least as slim as they were in 1979—probably a lot slimmer.

In addition, federally collected funds from Dingell-Johnson and Pittman-Robertson are shrinking for all states, and recent legislation split Washington's share of the D-J funds and gave part of them to the Department of Fisheries, making the Department of Game's share of the ante even smaller.

On the brighter side, the department's Citizens' Wildlife Heritage Program, which solicits donations of money and property from industry and private citizens, has generated some substantial financial results in recent years and will likely continue to do so. Besides outright gifts of money, the program has provided the department with some important donations of wildlife habitat and public access property.

The "Patron" program, wherein individuals, organized sport groups, and businesses would pay a $500 to $1,000 lifetime donation to wildlife-oriented activities, is being considered as a way to generate funds for the department in the near future. The donations would entitle the patron to lifetime fishing and hunting privileges in the state, if he or she so desired.

A group called the Coalition for Washington's Fish and Wildlife, comprising sportsmen, environmentalists, resort owners, and others concerned about the current state of wildlife funding in the state, may also provide financial relief for the Game Department. At this time, the Coalition is attacking the problem by developing a funding strategy that they will present as an initiative either to the legislature or directly to the people.

The success or failure of these and other programs is going to play a big part in determining the scope and success of Game Department programs in the near future and on into the 21st century. The public's need for fish and wildlife, protection of wildlife habitat, enforcement of the game laws, land acquisition for the good of wildlife and the public, and all the other responsibilities of the Game Department will continue. At this time it's difficult to say what level those needs will be met.

Missouri

Geographically in the continental United States, Missouri is a central state and now claims the nation's population center. It features a little of the north, the south, the east, and the west. Two major rivers—the Missouri and the Mississippi—traverse the state. Both come from the north, with the Missouri then crossing the state west to east. Some drainages feed into the Arkansas and White River basins.

Vegetatively, oak-hickory forests and bottomland hardwood types are found. Shortleaf pine, a southern species, is native to the Ozarks. Prairies once occupied broad reaches of western and northern Missouri, but now only remnants remain. Of its 44-million (17.8-million ha) acres, currently about 28 percent is forested, with the remainder primarily crop and pasture.

Two major urban areas—Kansas City and St. Louis—are located on the state's west and east edge, respectively. From a demographic standpoint, its 1980 population was 4.9 million, an increase from 1970 to 1980 of about 250,000. Forty percent of the population is in St. Louis City, St. Louis County and Jackson

County (including Kansas City). Statewide, 68 percent of the population is urban, a decrease of 2 percent in 10 years.

Agency Objectives, Organization, and Operations

The Conservation Commission of the State of Missouri is somewhat of a unique agency that originated because of citizens implementing the initiative petition process. It was formed as a constitutional agency by a direct vote of the people of Missouri. Their goal was to have a professional conservation department that was strictly nonpolitical. This occurred in 1936. At that time, strong and specific authorities for the fish, wildlife, and forestry resources were enumerated. Now, after the passage of almost a half century, that mandate has not changed. It remains with the fish, wildlife, and forest resources. The agency, through its operating arm, is usually referred to as the Department of Conservation. It has survived because of a proven track record in resource management. Professionally, it is stable as far as staff is concerned. Its stability, perhaps is best illustrated by the fact that in the 47 years of existence, the Department has only had four directors, each appointed by the four-man policy making Commission to serve at its pleasure.

The organization operates in a line-staff arrangement. The four principal divisions are Fisheries, Wildlife, Forestry, and Protection (in essence the law enforcement arm) with smaller Natural History and Conservation Education sections. Support comes from the usual functions—Planning, Personnel, Federal Aid, Land Acquisition, Information, Fiscal, Operations and Engineering. The Department has its own General Counsel and Internal Auditor.

Although operating on a line-staff basis with personnel slotted in specific divisions, sections, or units, the Department really functions as one unit. Each individual has characteristically become a crusader for the fish, wildlife, and forest resources. Interest and support among the units for the total program is extremely strong. For example, the Conservation Agent teaches hunter education classes, enforces the rules and regulations, oversees the operation of a Department area, and is the eyes for the environmental unit concerned with dredge and fill permit applications or stream channelization.

Agency programs are principally directed as follows: "To manage the state's fisheries, wildlife and forest resources in a way that will assure their continued, adequate availability for the enjoyment, recreation and economic benefit of Missouri citizens and visitors."

Funding Sources, Constraints, Commitments, and Trends

The Missouri Department of Conservation, being a constitutional agency, has always been a little different than most other Conservation agencies from its inception in the mid-30s until mid-1977. Still, hunting and fishing permits provided the financial backbone. Federal Aid funds of various kinds, including minor amounts of Land and Water Conservation Funds, special grants, gifts, etc. also contributed. Incomes from area management were earmarked for Department programs. Revenues, although appropriated by the Legislature, could only be spent upon direction of the governing four-member Commission. In 1976–77, General Revenue appropriations from other state income sources amounted to approximately $1.25 million. These funds were earmarked for the Forestry programs, primarily for fire control and forest management. Occasionally, special federal funds, such as Accelerated Public Works or Revenue Sharing were directed into specific Department programs.

Under those funding arrangements, the Department, because of its funding sources and earmarked nature of some funds, did not have sufficient funds or a broad enough revenue base to do the total job that was needed in resource management. Those that paid the bill—primarily the hunter and fisherman—although not demanding, still expected that those revenues would be primarily used to benefit the fisheries and the wildlife resources and also to provide opportunities for the enjoyment of Missouri's out-of-doors represented by hunting and fishing.

Dependence on the "traditional" sources of revenues made it impossible to properly serve the total public. There remained a feeling that to truly carry out a successful conservation program, it would be best for all to pay. In the early 1970s, discussions started on how to achieve additional sources of funding. Various ways were examined, including special fees, taxes, etc. One plan that was aborted in the courts involved imposition of a "soda pop" tax. Even though petitions were circulated and the required number of signatures of qualified voters were obtained, the Courts found a petition wording error which forced the scrapping of this source.

The need for a broader funding base still remained. This was solved in 1976, when again, through the initiative petition process, a Constitutional Amendment was brought to the people of Missouri for their vote. It provided for a one-eighth of 1 percent sales tax, with all funds earmarked for Conservation Department expenditure on the fish, wildlife, and forestry programs. The public approved the proposal which was tagged "Design for Conservation." Existing sources of funds were continued for the most part; however, with the new program a much broader base of conservation issues related to the fish, wildlife, and forest resources could be addressed.

Yields during the first five years of the program (1 July 1977 to 30 June 1982) totaled about $148,000,000, an average of approximately $30,000,000 per year. Inflation, a stagnated economy, etc., has in reality shrunk the buying power of these dollars since the initial years of the new program. However, the sales tax revenues, constituting over half of the total Department income, have been sufficient to greatly expand the Department efforts.

During this same five-year period, traditional sources of income yielded about $100,000,000. Hunting and fishing permits contribute in the range of 22–23 percent of the budget annually.

Pledges and promises were made prior to the vote on the sales tax, some of which would use part of the new funds. Included was a Department promise that since it was going into an accelerated land acquisition program, in-lieu of tax payments would be made. This now amounts to about $400,000 annually. The State Department of Revenue, which collects and disburses the sales tax, receives a portion of the total, some $260,000, as a collection fee. General Revenue Funds, which had previously totaled approximately $1.25 million annually for the Forestry program, were immediately withdrawn upon approval of the new funding source. Programs funded at the federal level, such as the Land and Water Conservation Fund, which other local and state agencies were also eligible for, became virtually non-available to the Department—a result of other governmental entities being less well funded.

Other agencies tended to look at the Department as "the rich uncle" which needed no additional funds with which to operate. Repeated attempts have been made by legislative interests to tap the funds for everything from metropolitan sewer projects to soil erosion control efforts, and even to funding the State Park system. Other state agencies were even offered to the Department for administration with the goal being to release General Revenue Funds. Certainly, having a well funded department brings it certain trials and tribulations.

The Department must and does work hard to carry out its program to fulfill all promises made, such as land acquisition, increased and improved services, and additional emphasis on management and research. By its vote, the Missouri public placed a special trust in the agency. A failure to live up to that trust could relegate the program back to its pre 1 July 1977 status with the much smaller "traditional" income sources available for funding.

Budget Limitations and Their Effects on People

Professionals of vision certainly see unlimited conservation and public use horizons for which available funds could be expended. A major problem in implementing a new program in a short time is to start making good on promises while taking great care to not waste funds and become bogged down with programs, personnel, and projects that can in the long run more than use up the sums available. Permanent personnel are an example. Once aboard, the individuals represent fixed and constantly increasing costs to be taken off the top year after year. This may occur at the expense of promised new or accelerated programs.

Certainly, additional personnel were needed to handle a more than doubled Missouri program previously involving about 850 full-time staff. The Department of Conservation has always added additional personnel with care; even so, permanent staff has necessarily increased by about 200 since 1977.

Effects of inflation on the purchasing power of the dollar and the generally increasing costs of everything has meant in Missouri and elsewhere that the net value of the dollar received constantly decreases; an agency establishing a program solely based on dollars without consideration of buying power could quickly find itself in financial trouble.

As promised by the Department prior to the citizen vote on the increased funding, personnel were added soon after the new sales tax revenues became available in July 1977. Included was a 15-person Natural History Section staff to deal with endangered species, natural areas, nongame wildlife, and similar generally inadequately addressed resource fields. Thirty new conservation agents give more intensive coverage of the state, additional realty staff handle land purchases, etc. By contracting and using temporary or fixed-term employees, permanent staff numbers can be stabilized and overhead costs maintained at a reasonable level.

The major program promised during the initial years of new funding was to accelerate greatly land acquisition. This has been done through the expenditure, during the first five and one-quarter years of the new program, of over $100 million for purchase in fee title of some 142,000 acres (57,510 ha) of land. Included are lake sites, forests, wetlands, bat caves, stream access and stream frontage sites, upland wildlife areas, glades, etc. Land acquisition, as a program, can be quickly turned on and off. Even so, more personnel are needed to conduct management activities on the areas acquired. After acquisition comes development with its need for special services—engineering, construction, and management. Operation and maintenance then become a long-lasting and continual burden to be contended with as funds and personnel are involved.

Another unseen or unrecognized problem area concerns other state agencies suffering from inadequate or declining revenues—whether from a special tax such as on gasoline, from general revenue funds, from tax sources, or from federal grants. It is most difficult for an agency viewed as "being rich" to not become a target to be envied and discussed by both other governmental bodies and the public.

Too, the idea of increasing fees or charges from the "traditional sources of income" may be challenged. Even though all Missourians now pay something to fund the Conservation Department, the direct users—the hunters and fishermen—still pay more. How can increased prices for hunting and fishing permits be justified even if the intent is to overcome inflation or to stay even with an adjoining state? Achieving new or increased funding without incurring the real or imagined wrath of the legislature and the public and being tabbed as "greedy and money hungry" can be a definite problem. Wise fund management and good public relations strongly backed by an active, positive Department program are keys to minimizing budget constraints.

Agency Functions

The Missouri Department of Conservation has as its specific charge "The control, management, restoration, conservation and regulation of the bird, fish, game, forestry and all wildlife resources in the state including hatcheries, sanctuaries, refuges, reservations and all other property owned, acquired or used for such purposes in the acquisition and establishment thereof and the administration of all laws pertaining thereto. . . ." These are specific legal responsibilities; however, over the years interpretation has been that providing facilities for public use to foster the use and enjoyment of the resources are well within the program. Parks are not included. They are in the Department of Natural Resources, another of the 13 departments of Missouri State Government.

Conservation is a program of service to the people and to Missouri's rich out-of-doors. It is basically a three part program revolving around conservation lands, public services, management, and research. The Department of Conservation has demonstrated the capability to conduct the full range of programs, including those strongly oriented to the nonconsumptive user.

The Department on 1 July 1977 owned in fee title about 300,000 acres (121,500 ha). In 5 years, it has acquired an additional 142,000 acres (57,510 ha) of its goal of 300,000 additional acres (121,500 ha). Land acquisition emphasis remains a priority item in the overall program. Coupled to the acquisition program is an active donation and gift program where monies, other items of value, and lands are given to the Department for its programs. To stretch its program dollars, the Department leases or licenses for its purposes other lands totaling over 260,000 acres (105,300 ha).

Emphasis in education has developed into a strong working relationship between the Department's Education Section, the state education officials, and the schools, from elementary through college. The remarkable K–8 (kindergarten through grade 8) program is being expanded to grades 9–12, and even to pre-kindergarten. About one-third of a million students are being reached monthly along with some 13,500 teachers by providing structured educational materials in packets for classroom use.

Interpretive programs range from outdoor classrooms on school or other close by public properties to special activities to which the public is invited—"Eagle Days," "Prairie Days," "A Day in the Forest." A major interpretive center, Burr Oak Woods, was opened in 1982 east of Kansas City.

A new 15-staff Natural History Section was established in 1977. It functions in the broad area of nongame species, rare and endangered species, and the gathering and publicizing of information on the unique things of Missouri. Included are activities to identify rare or unusual plants, carefully inventory caves on all segments of public lands, and locate and bring into public ownership unique areas statewide.

Major efforts are underway to re-establish species formerly native to Missouri. Included is the importation, with help from our northern friends, of a family of trumpeter swans to the Mingo National Wildlife Refuge in southeast Missouri. Hopefully, these majestic birds will become imprinted to Missouri and return to restablish a population. The ruffed grouse re-establishment program has expanded from the Missouri River Breaks to the Ozarks. It appears to be going well. River otters, a rare breed in Missouri, have been, with assistance of our southern cohorts, moved to the Swan Lake National Wildlife Refuge in north central Missouri on an experimental basis.

Cave inventories have identified several species of invertebrates previously unknown any place in the world. Funding assistance is provided to the raptor rehabilitation center at the Springfield Zoo and the Tyson Research Center for its red wolf project near St. Louis. A barn owl management program is going well. Shooting ranges are being established both on Department lands and cooperatively with clubs and organizations in local areas. Lakes are being built, stream access developed, and waterfowl areas acquired and established.

Concern for the fish, wildlife and forest species also brings the Department into close contact with the habitat base—the soil and water resources. It's an active leader in promoting clean water and reduction in soil erosion. An effective statewide wild fire prevention and control program is ongoing. This is being accomplished directly by the Department and on a cooperative basis by providing seed money to local fire departments and control organizations.

Research and resource management is geared to obtaining good data on the stream, wildlife, and forest resources of the state, on the users of the lands and waters, and on public attitudes.

Public opinion or attitude surveys are a cooperative venture involving the Department's Planning Section, its fish and wildlife research units, and the Department's program divisions, sections, and units. Sophisticated survey techniques are used to gather information on public thinking as an aid in program planning and resource management. The information gathered has been more useful to the Department staff, as survey results are often different than anticipated.

A major Natural Area program is designed to bring under protection unique ecosystems and geological features statewide on public and private lands. The goal is to designate formally the best representative areas in Missouri for protection for their future scientific values and for enjoyment.

Information programs are geared to reach the broadest segment of the public possible. Department demonstration farms are established in northwest and southwest Missouri to show that good agricultural practices and wildlife management can mesh. These are opened to the public for viewing and study.

Urban fishing programs are established in the major urban areas and are being expanded. Cooperative municipal lake programs can serve communities where public waters exist. The Department role is to supply funds to provide management assistance and to develop the municipal area for public use.

The bottom line is that the Missouri Department of Conservation has an aggressive broad-based, ongoing program and the capability to carry it out. Both nongame and game species are considered. Commercial forests as well as the lesser forest species, such as might be found in glades or wet bottoms, are recognized. Minnows have assumed importance as have the game species. Nonconsumptive users have much the same opportunity to enjoy the Missouri resources as the consumptive public. The Department's view is that overall program productivity is the key to survival.

Provincial Wildlife Revenue Sources and Commitments

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The objective of this paper initially was to present the "Canadian situation" relative to revenues and expenditures in wildlife management . . . a rather dry task for two wildlife biologists turned administrators. However, after examining the recent growth in expenditures compared to revenues, and after examining all the diverse funding sources associated with fish and wildlife programs, the task became an opportunity of considerable value. As a perspective on the past and a look into the future, the results of the review were a shock. Perhaps wildlife managers have been more innovative and successful than recognized.

A comprehensive survey conducted by Statistics Canada in 1982, sponsored by federal, provincial and territorial government wildlife agencies and a number of nongovernment groups, revealed that Canadian wildlife resources were highly valuable to the nation. Wildlife-related activities emerged as one of the most prevalent forms of recreation undertaken by Canadians. Participants provided an important stimulus to the Canadian economy by spending an estimated $4.2 billion on wildlife-related activities. This estimate excluded the commercial value of wildlife. About 83.8 percent of the Canadian population participated in some form of indirect wildlife-related activity in 1981. Approximately 8.1 million Canadians encountered wildlife during trips or outings taken primarily for business or pleasure. About 93 percent of them declared that such encounters increased the enjoyment of their trip or outing significantly. These unplanned encounters with wildlife resulted in the spending of a significant amount of extra money during these trips, averaging $10 per participant and totalling approximately $85 million in 1981. As many as one out of every five Canadians undertook a special trip or outing in 1981 for the primary purpose of observing, photographing, feeding or studying wildlife. During such trips, Canadians spent a total of $2.1 billion. Hunting attracted one in every 10 Canadians in 1981. Participants spent an estimated $1.2 billion, or about $602 per hunter, with the average hunter spending about 17.9 days hunting during the year. The survey also revealed that Canadians value the conservation of wildlife. About 80 percent stated that maintaining abundant wildlife was important to them. Thus, there exists a broad base of support for wildlife management in Canada, despite the fact that government fish and wildlife agencies do not have access to user-pay funding as is the case in the United States.

The Canadian fiscal approach reflects the British Parliamentary system of not allowing the appropriation of revenues back to specific revenue-generating programs. Wildlife agencies, therefore, cannot utilize revenues obtained by royalties, license fees, fines or from rental of lands dedicated to wildlife conservation. This approach has significant benefits as most wildlife agency expenditures from general revenues far exceed the direct income.

In Alberta, expenditures started to exceed revenue in the late 1960s. Twenty years later revenues are only equal to 33 percent of the Fish and Wildlife Division's operating budget. In Manitoba, direct revenue to government from wildlife licenses and royalties is equal to about 40 percent of the Wildlife Branch's annual expenditure. In other words, if a "user pay" philosophy were adopted, there would have to be a significant curtailment of programs, a substantial increase in fees, or a mechanism to tax all users. There are some obvious benefits to the Canadian approach, particularly with the reduced emphasis on revenue-generating programs to fund the management of all wildlife. However, this revenue/expenditure comparison should be examined in the context of the capital value of fish and wildlife resources and their value to the respective economies of Alberta and Manitoba. In Alberta, for example, economists have calculated the capital value of the fish and wildlife resource to be $4 million. In addition, they have calculated an extra market benefit of $200 million annually. In general, the net economic benefit to the Province is 13 times the provincial expenditure on fish and wildlife management.

In Manitoba, direct revenue to the provincial government from license fees, royalties and taxes raised directly from consumptive and nonconsumptive uses of wildlife is estimated to exceed $7 million. However, the total value of wildlife to the provincial economy exceeds $250 million per annum. Thus, for every dollar spent by the Manitoba Wildlife Branch, the provincial treasury gets two dollars in return. More importantly, for every dollar spent by the Wildlife Branch, 66 dollars are generated in the provincial economy. Hence, the provincial Wildlife Branch's budget represents less than 2 percent of the value of wildlife to the provincial economy.

In examining Figure 1, there appears to be a dramatic surge in the Alberta Fish and Wildlife Division's budget during the past decade, which is also reflected in a significant increase in manpower. While there has been an upswing in growth, a large proportion reflects inflation and union contracts. A review of real growth within the Manitoba Wildlife Branch during the ten-year period 1964–65 to 1974–75 indicated an annual real growth of 3.5 percent. This review also showed that wildlife program expenditures grew half as fast as expenditures in the public sector as a whole. The Renewable Resource sector of the Department in Manitoba comprised 2.6 percent of the provincial expenditure in 1964–65, but only 1.3 percent by 1974–75.

While the Canadian system of separating revenue and expenditure has major benefits, there are problems. Many are related to the confusion of roles and responsibilities for wildlife management among levels of government, although it is generally recognized that the provinces have the prime responsibility. Other problems are related to the past lack of clear governmental policies on wildlife, with commitments to achieve finite recreational goals based on supply and demand criteria. The growth of the environmental movement, rather than strengthening the role of the wildlife management agency, often created new "environmental" agencies and legislative requirements that competed for scarce fiscal resources. Inability to use direct revenue from lands designated for wildlife has reduced the opportunity and motivation for multiple use of these lands and, therefore, dedi-

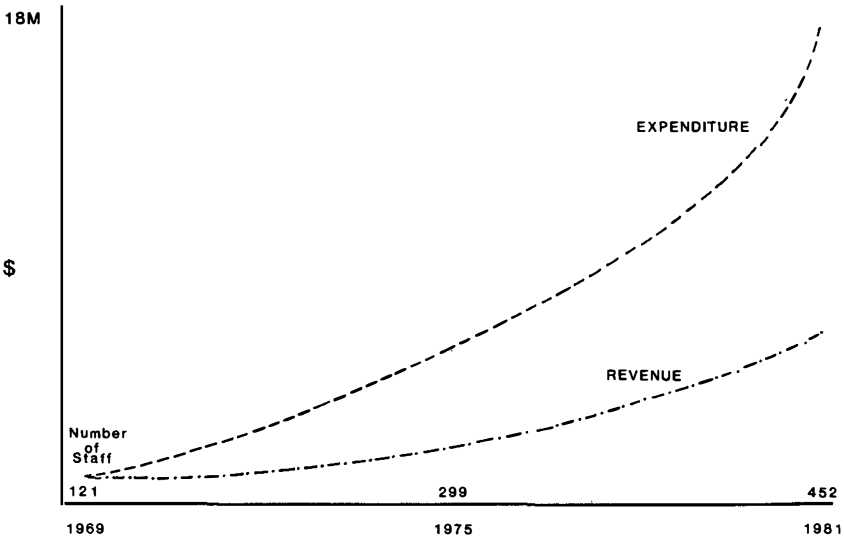

Figure 1. Relationship of revenue to expenditure in fish and wildlife management in Alberta.

cation of further wildlife areas. An additional problem is the lack of proven integrated management strategies and tools. Comprehensive inter-agency solutions to protect and enhance wildlife are difficult in a fixed and vertical organizational structure with limited statutory capability for innovation.

In recognition of these problems and the requirement for general revenue to provide for broad-based management programs, there has been a growing view that users should pay, directly or indirectly, for special management programs. In the past few years this has led to a high degree of innovation and the dependency on other sources of funds as shown in a series of graphs identifying the total expenditure for fish and wildlife management in Alberta in 1981–82.

Figure 2 simply illustrates the Alberta Fish and Wildlife Division's budget, broken into six functional programs. The total of $15 million is three times the Government's revenue obtained from fish and wildlife resources.

Figure 3 illustrates additional provincial funds assigned to the Division based on funds from special levies on sportsmen for habitat and crop protection programs and from industry for compensation payments to trappers as shown by the cross-hatched portion of the histogram.

Figure 4 illustrates the degree of cooperative funding with Divisional fish and wildlife programs. A large proportion of wildlife management programs are funded with other agencies. Most programs are obvious, such as other departments providing services from hatchery construction by the Public Works Department to habitat enhancement by the Transportation Department. Many were created due to our inability to provide an adequate service, such as the agricultural and municipal funding of problem wildlife control. Other areas are related to nongovernment organizations providing significant support, such as Ducks Unlimited capital construction on Crown land. And finally, others are related to the sharing of respon-

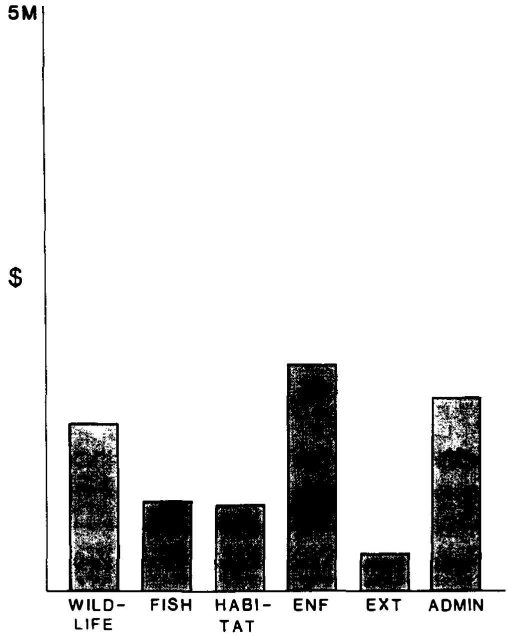

Figure 2. Expenditures for fish and wildlife management in Alberta, 1981–1982, from provincial appropriations.

sibilities for some management programs, such as the Federal Government's participation in waterfowl crop damage compensation and efforts on endangered species.

An interesting observation of the degree of fiscal participation by outside agencies can be seen by examining the reduced expenditures on wildlife research by provincial wildlife agencies. For example, during 1982–83 the Manitoba Wildlife Branch spent about $285,000, or about 8 percent of its budget, on what might be termed "research"—studies designed to solve specific management problems. The proportion of effort being devoted to wildlife research by cooperating private and public agencies has helped offset the trend of reduced emphasis on research by the Province. For example, in 1982–83 agencies other than the Manitoba Government devoted some $1.9 million to wildlife research, which is equivalent to 53 percent of the Wildlife Branch's budget for that year and seven times that identified for their research program.

Figure 5 identifies the large funding commitment from indirect sources that we are only beginning to exploit. These "opportunistic" funds primarily relate to industrial development and the legal requirements for impact assessments and mitigation. Compensation for the loss of wildlife habitat is not a major tool in Canada, although recently there have been several cases in British Columbia. There is no clear estimate of the extent of mitigative costs, some by industry, although we do know that some of our conditions for the approval of industrial developments can cost over a million dollars each, such as requesting directional

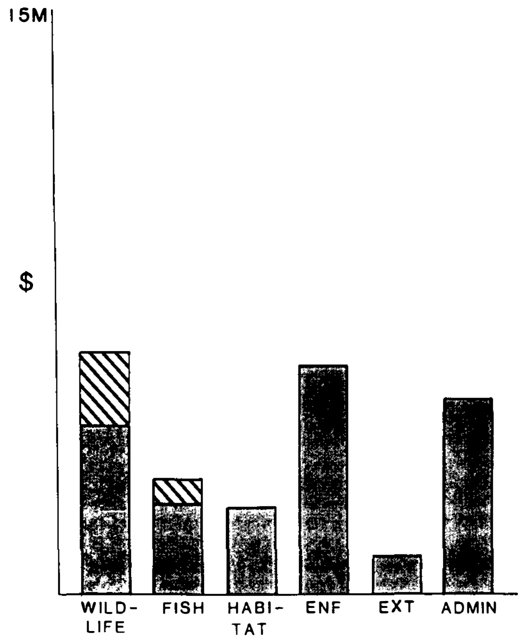

Figure 3. Expenditures for fish and wildlife management in Alberta, 1981–1982, from provincial appropriations (solid) and assigned funds from identified revenues (diagonal lines), including trapper compensation, Wildlife Damage Fund, Fish and Wildlife Resource Development Fund, and Heritage Savings Trust Fund.

drilling or power line alignment modifications. Staff estimate the annual cost for mitigation in Alberta between $10 million and $50 million. The minimum $10-million estimate is identified in Figure 5 with a broken line as it is not a finite figure and cannot be shown to scale. There is no estimate for the cost of lost revenue or loss of Crown royalties. Also recognized in this figure is the funding from a third share of the provincial lottery revenue for fish and wildlife research.

Figure 6 represents the independent funding of other agencies in fish and wildlife management. All are complimentary, such as the various components of the Federal Government, including the Canadian Wildlife Service, National Parks, and the Royal Canadian Mounted Police. Also identified are the United States Fish and Wildlife Service waterfowl program and, of course, Ducks Unlimited.

The sum of all these programs is revealing, as similar to the review of research in Manitoba, that the main-line budget is a small percentage of the total. For example, the provincial wildlife component of the budget is 29 percent of the total program cost and eight times the revenue. In habitat management, the direct provincial contribution is 10 percent of the total program cost, including industry's minimum $10-million mitigation costs, but not the loss of potential revenue and royalties to the Crown.

Although the scale of expenditure differs from Alberta to Manitoba, the trend is the same. Provincial financial allocations to wildlife are but a fraction of the

Figure 4. Expenditures for fish and wildlife management in Alberta, 1981–1982, from (A) provincial appropriations; (B) assigned funds from identified revenues; and (C) cooperative funding, including from provincial agencies, federal agencies, and public organizations.

combined total expenditures for wildlife management by all agencies. The component which differs the most between Alberta and Manitoba is funding provided by the industrial sector for mitigation, particularly for oil and gas development. Although this is substantially less prominent in Manitoba, hydro developments in that province are now resulting in significant funding for wildlife mitigations. Thus, it is obvious that over the past couple of decades there has been a shrinking proportion of the provincial budget going toward fish and wildlife management through the responsible government agencies. However, this has been more than offset through increased spending for fish and wildlife mitigation and enhancement by cooperating agencies and industrial developers.

After reviewing revenue sources and examining the multitude and complexity of issues facing wildlife management, it is clear that additional initiatives are required if fish and wildlife populations are to prosper in the decades ahead. The most obvious and promising which are already underway in some jurisdictions are:

1. Mechanisms to protect and enhance wildlife habitat beyond outright public ownership, i.e.,
   a. support for and strengthening of existing land use policies that protect habitat;
   b. alteration of tax structures to provide incentives to encourage habitat on private land;

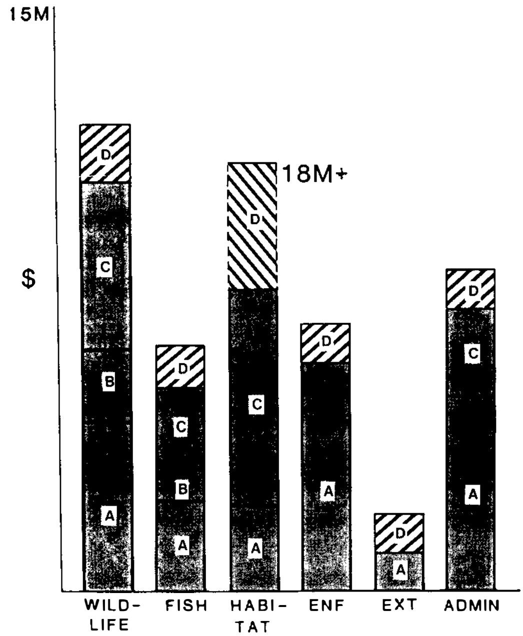

Figure 5. Expenditures for fish and wildlife management in Alberta, 1981–1982, from (A) provincial appropriations; (B) assigned funds from identified revenues; (C) cooperative funding; and (D) opportunistic funding, including manpower, lotteries, and industry.

c. more effective integration of wildlife habitat needs into the plans and operations of major land users;
d. encouragement and direction to private conservation organizations that have a capacity to protect and/or enhance wildlife habitat; and,
e. permission and encouragement to the private landowners to derive income and other benefits from the use of wildlife inhabiting their properties.

2. Greater wildlife production from lands that are now set aside, wholly or in part, for wildlife.
3. Greater control over the harvest of wildlife.
4. Greater attention to the management of rare, threatened and endangered wildlife.
5. Development of an administrative climate which fosters and encourages cooperative initiatives between all levels of government and between the private sector and government.
6. A much stronger advocacy for wildlife.
7. Improved programs to prevent and/or compensate for damage inflicted upon landowners by wildlife.

We are optimistic that new fiscal initiatives will be developed to tackle these areas by further innovation and continued cooperative arrangements rather than through additional direct funding from provincial appropriations. Most of these initiatives fortunately do not require major funding during this period of fiscal restraint, but require emphasis in policy and public commitment.

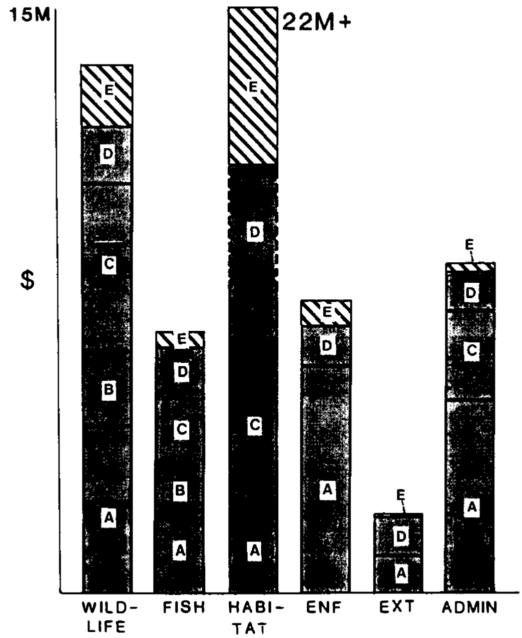

Figure 6. Expenditures for fish and wildlife management in Alberta, 1981–1982, from (A) provincial appropriations; (B) assigned funds from identified revenues; (C) cooperative funding; (D) opportunistic funding; and (E) separate programs by other agencies, including federal agencies, U.S. Fish and Wildlife Service, sportsmen, Ducks Unlimited, and universities.

Although Canada still has a rich wildlife resource, recent demands upon it for subsistence, recreational, and commercial uses point up its limitations and vulnerability to exploitation. Industrial and agricultural development have exacted a toll which only recently has been ameliorated by mitigative efforts. The past abundance of fish and wildlife in Canada may have lulled managers and users into a false sense of security. In any case, it is now evident that the resources are being assaulted heavily. However, mitigative efforts, designed and implemented with imagination and commitment, can offset much of the impact of such exploitations. This means that public policy respecting developments that could affect fish and wildlife may become equally important to funding allocations in the maintenance and enhancement of fish and wildlife resources. Herein lies the challenge.

In summary, we have attempted to illustrate the "Canadian" approach of general revenue appropriation for fish and wildlife management. Funding of management programs has become very complex with the integration of private, government, and industry programs. It is obvious that general revenue funding cannot meet the costs of management at the current level of sophistication required in an industrial/agricultural area. While a number of funding initiatives have developed, new ones will be required to meet the challenges of the future. Success, however, will not be related to the size of budgets, but to our continued ability to influence the impact of major financial and land use institutions within society. Perhaps we are beginning to meet the challenge.

Using Nonprofit Organizations to Manage Public Lands

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The public sector fiscal crisis is by now a widely-recognized problem. For a variety of reasons, federal, state, and local governments are finding it increasingly difficult to pay for necessary public services. Public recreation, wildlife management, and land protection programs are faced with rising expenditures and stable or declining revenue sources. In Michigan, for example, the wildlife division of the state natural resources agency is facing a 12 percent reduction in its operating budget this year and expects a further reduction in fiscal year 1984. To solve these problems, many public agencies are exploring creative financing strategies, including various approaches that involve alternative managers who can provide public services at lower cost with equal or higher quality. As the fastest growing sector of the economy, the nonprofit sector, including groups such as the Boy Scouts and the Audubon Society, has been seen as one source of alternative management expertise. Nonprofit organizations are viewed to offer many of the benefits of a private business without the need to make a profit.

Nonprofit organizations constitute a significant third sector of the economy. In 1980, outlays of philanthropic organizations totalled over $120 billion, accounting for roughly 4.7 percent of the GNP. Philanthropic organizations employed some 5.6 million salaried workers in 1980—5.7 percent of all workers. Nonprofits are particularly attractive as one solution to the fiscal crisis because they receive little government financial support. In 1980, for example, philanthropic organizations raised about half their operating revenues from sales and half from subsidy. Only 6 percent of their revenues came from government grants (Rudney 1981).

Nonprofit organizations are involved in public lands management in a variety of roles, and provide numerous services such as management planning, land acquisition, site maintenance, and user education. Wildlife-oriented nonprofits are involved in land acquisition programs for the support of game and nongame animals, fund-raising efforts to support state wildlife programs, and maintenance activities to enhance wildlife habitat. Other groups monitor wildlife populations, maintain hunting trails on public lands, manage zoos and museums, and provide public education programs. In Wisconsin, for example, the Prairie Chicken Society has acquired 11,000 acres (4,455 ha) of prairie chicken habitat that is managed by the state. In Kansas, the local chapter of Safari Club International is financing the state fish and game commission's efforts to reintroduce the ruffed grouse into the state. The Desert Volunteer Program in California organizes workers from various nonprofit groups in the state to survey and monitor bighorn sheep populations and to install devices in remote areas that provide water to wildlife populations. In Arizona, the Bighorn Sheep Society maintains habitat on both state and federal lands. While maintaining grouse and Canada goose habitat on state lands, Michigan Wildlife Unlimited cuts trails for hiking and hunting purposes. The Massachusetts Audubon Society manages the Trailside Museum, a natural history museum that includes a small zoo, for the Metropolitan District Commission, a substate regional agency.

Cooperative working relationships between public agencies and nonprofit groups come in many shapes and sizes. Many agencies use volunteers directly. For example, both the Pennsylvania and Nevada parks departments have "volunteers in parks" programs. Agreements with nonprofits vary by degree of formality, including simple working relationships characterized by personal interaction with no written agreements, memos of understanding for specific projects or services, and management partnerships defined by formal cooperative agreements. The most formal relationship involves contracts or grants for specific projects or services.

As public agencies increasingly become involved in cooperative agreements, questions arise as to the benefits, costs, and effectiveness of such working arrangements. This paper focuses on three questions.

1. How do nonprofit groups and public agencies differ in the way that they provide comparable land management services?
2. What problems tend to occur in cooperative agreements between nonprofits and public agencies?
3. How can public sector managers enhance the success of their cooperative working arrangements with nonprofit groups?

The conclusions presented in this paper are based on a two-year study undertaken for the Office of Policy Analysis, U.S. Department of the Interior. The study included an in-depth evaluation of four nonprofit-public sector cooperative agreements in the recreation field, and national surveys of state recreation and wildlife agencies, National Park Service regional offices, and nonprofit organizations (Yaffee 1982).

Differences Between Services Provided by Nonprofits and Public Agencies

Creativity/Flexibility

One of the arguments that proponents of cooperative agreements make consistently is that nonprofit organizations undertake land management services more creatively than public agencies. While the evidence is not entirely conclusive, my research generally supports this argument. Nonprofits often have the capability to perform creatively because of a more flexible perspective on staffing arrangements, and because they are not constrained by many public sector procedures and guidelines.

Nonprofits sometimes possess skills that are not replicated in public agencies. In Massachusetts, for example, nonprofits are much more capable than the state at providing interpretive programs and mobilizing volunteers. In Arizona, the state outdoor recreation and game and fish agencies contract with The Nature Conservancy to run a natural heritage program because the state agencies lack the staff capacity to run the program themselves.

Nonprofits often can be more creative because they are flexible about ways to obtain and employ resources. Public agencies often view their potential program resources as limited by available staff and budget. Many nonprofit organizations, on the other hand, are accustomed to a variety of voluntary, paid, and reimbursement staffing arrangements, and regularly solicit contributions of time and expertise from their members and other interested parties. For example, in helping the Massachusetts Department of Environmental Management (MDEM) prepare a management plan for the new Halibut Point State Park, the nonprofit Trustees of Reservations was able to solicit voluntary contributions of time from an architect, several scuba divers, and thirty individuals with natural history and interpretive skills. The ability of an organization to find appropriate expertise clearly depends on the group's membership and connections, as well as its past interest in ferreting out appropriate short-term and voluntary workers, but groups with decent "scavenging" abilities are often able to "out-expert" many public agencies.

A nonprofit's relative ability to operate innovatively may have less to do with its innate talents than with constraints on the public sector's ability to be creative. Legislative or administrative requirements may constrain the quality or characteristics of an agency's staff. In addition, public agencies are usually guided by a set of operating procedures that reflect notions of professionalism and tradition as well as administrative and legislative mandates. By insuring consistency in operations throughout a large organization, institutional norms and operating procedures can limit the creativity or flexibility of an agency's service provision. For example, in maintaining hiking trails in the White Mountain National Forest (WMNF), the U.S. Forest Service must follow the provisions of the Fair Labor Standards Act which requires that overtime be paid to employees working more than eight hours per day. The act and the Forest Service's traditions lead to a "nine to five" maintenance program. The Appalachian Mountain Club (AMC), which maintains some 20 percent of the trail mileage in the White Mountains, is not similarly constrained; it can arrange its maintenance schedule very flexibly.

Public agencies are often constrained in their approach to service provision because they have to respond to broader constituencies with diverse demands. Fewer approaches are possible that will simultaneously satisfy different agency client groups. In the WMNF, for example, the Forest Service is constrained in the kind and quality of trail signs that it posts because of the necessity to use signs produced by the federal prison industries. The AMC, on the other hand, employs a "sign person" who hikes from sign to sign preparing them on the spot.

While nonprofit organizations are not constrained by many of the factors that affect public agencies, they may be limited by their own standard operating procedures. For example, MDEM contracted with AMC to construct a new statewide trails organization, yet the success of the project was limited by AMC's approach to organizational networking. To construct the new group, AMC used its "old boy network," which consisted primarily of AMC members. New volunteers were not solicited. AMC's staff was constrained by its normal way of doing things. Indeed, the group that the AMC put together not surprisingly said that no new organization was needed, since AMC already represented their interests.

While nonprofits may at times be blinded by their standard ways of doing things, they most likely still have an edge over public agencies in being creative and flexible. Some of the advantages provided by nonprofits may be reduced if constraints are written into cooperative agreements. Clearly one question that needs to be addressed regarding the procedural differences that allow nonprofits to be flexible or creative is whether legitimate employee concerns that are protected by regulations are being overlooked or avoided by using nonprofits.

Cost-Effectiveness of Cooperative Efforts

The proponents of nonprofit-public agency cooperative agreements almost always argue that nonprofits can manage land and provide public services at lower costs than those incurred by public agencies. My research suggests that cooperative relationships can be a cost-effective management device when viewed from the perspective of a government agency or the government as a whole. For example, the AMC's costs for trail maintenace in the White Mountains average from 22 to 80 percent less than those of the Forest Service. In the three cooperative agreements that I studied in Massachusetts, the rate of return on the public sector's investment ranged from 66 to 125 percent—a good deal indeed. Some of this payoff may be illusory because the nonprofit's contributions are generally taken from membership contributions. Such contributions are tax-deductible; hence, they ''cost'' the government tax revenues. Still, considering tax revenue losses, the rate of return of the Massachusetts' efforts were in the range of 36 to 59 percent.

Nonprofits often reduce their costs by using temporary personnel and volunteers, paying their permanent staff at low rates, and achieving high rates of worker productivity. Temporary workers are cheaper than permanent staff because an organization does not have to pay for health care and retirement benefits, and does not have to include their salaries as an overall fixed cost. In addition, a nonprofit can often solicit highly-motivated temporaries who will perform a task at less-than-market rates because they are receiving nonmonetary benefits as well—either out of self-interest such as gaining experience or out of a cause-orientation.

While nonprofits differ in the degree to which they use voluntary labor, the use of volunteers can cut out large portions of a nonprofit's budget. Using volunteers is not costless, however. Recruitment, training, and supervision costs are significant and require skilled paid staff to carry them out. Since recruitment, advertising, and training costs are incurred up-front, volunteer programs are cost-effective only if they attract adequate numbers of individuals with the necessary qualifications. In spite of this, the use of volunteers is clearly one of the major contributions to the cost savings offered by a nonprofit. The overall cost advantage decreases whens the use of volunteers is limited. Some nonprofit groups see themselves as professional and not voluntary organizations and, hence, will not offer the cost advantages of a volunteer-based organization.

A third major way that nonprofits save on program costs is by paying their workers fairly low wages. For example, to run an interpretive program at Robinson State Park in Massachusetts, the nonprofit Hitchcock Center for the Environment used an interpreter who grossed $3 per hour, lower than minimum wage and less than half what a comparable state job would pay. If public sector agencies expand their use of nonprofits, one issue that should be addressed is the equity of underpaying workers. In essence, a cooperative agreement allows an agency to substitute low wage non-profit staff for market-rate government workers. Equity considerations become most important when the nonprofit labor market totally supplants the public sector market so that an individual's choice is not between working for the government at market-rate wages or working for a nonprofit at low wages, but between working or not.

Nonproft organizations also cut costs by following procedures that differ from those of public agencies. For example, AMC crews in the White Mountains use far fewer pieces of safety equipment than are required for Forest Service crews. Most nonprofits can contract for short-term work relatively easily and quickly. They do not have to follow federal or state requirements for competitive bidding, affirmative action, and small business promotion. Nor do they have to follow civil service and union regulations in dealing with their staffs.

While there are savings possible in the use of nonprofits, the cost advantages may be displaced somewhat by "hidden" costs associated with cooperative agreements. Setting up a cooperative agreement or contract often requires a fair amount of staff time from both nonprofit and public agency. Costs incurred by the public agency to aid the nonprofit in providing the service should also be factored into the cost calculation. These costs may simply equal the cost of maintaining communication throughout the course of the project, or be more substantial, such as the staff time required to generate data or maps for use by the nonprofit.

Even though nonprofits appear to offer cost advantages to the public sector, agencies should be cautious about plunging ahead with indiscriminate public funding or support of agreements. The decision on whether a nonprofit should be employed to provide a "public" service (and on how much to reimburse them) depends a great deal on the program's beneficiaries. If the beneficiaries are by-in-large members of the nonprofit, there is not necessarily a reason for the public sector to be involved in buying services. Simply because a nonprofit can provide a service cheaper does not mean that the public should be involved in it.

Role and Project Perceptions

Nonprofit-public sector cooperative agreements should not be viewed from the perspective of "normal" public-private contractual arrangements. These are not purely fee-for-service relationships; rather they provide seed money or other support for nonprofit ventures. Nonprofits do not generally get involved in these agreements for the money. They get involved in order to further their own goals and objectives. As a result, cooperative agreements are very different from public agency contracts with for-profit enterprises and generate a completely different relationship between client and contractor. Many public agencies do not understand the difference between a contract and a cooperative agreement, and try to view nonprofits as either other private contractors or as public agencies like themselves. Neither of these models is correct, however. Nonprofits are a unique type of service provider.

Since nonprofits do not generally pursue cooperative agreements for monetary reasons, it may be difficult to find groups willing to take on many tasks. Even if a nonprofit can be found to provide a public service, it may well provide a different kind of service than that contemplated by the public agency. Different approaches to service provision come from disparate notions of the goals of the service, and more importantly, who is to be served by it. All viable organizations have constituencies—individuals or groups who support the organization and are serviced by it. There is no reason to believe that nonprofit organizations and public agencies will have identical constituencies. Nor is there a reason to believe that simply because a nonprofit is operating under a cooperative agreement that it will significantly change its perception of its clientele or appropriate role. Clearly there are benefits for groups to participate in cooperative arrangements, but since their primary motivation is an opportunity to further their organizational mission and not to acquire dollars, one should not expect them to deviate very far from that mission.

One of the best illustrations of how different role perceptions and constituencies affect public service provision lies in the different perceptions held by the Forest Service and the AMC of their appropriate roles in providing trail maintenance in the White Mountains, and how these perceptions affect the way that they provide service. The AMC views itself as an advocate of skilled hikers; the Forest Service views itself as a steward of the public domain. The AMC primarily serves an affluent, moderately-athletic clientele whose major interests are hiking, camping, and related outdoor activities. The Forest Service, on the other hand, responds to a range of interests including logging, mining, and watershed protection; its constituents that use trails include snowmobilers and equestrians, as well as pedestrian hikers who range in ability and condition from out-of-condition and inexperienced to very capable. The ways that the AMC and the Forest Service maintain trails match their different constituencies. The Forest Service is particularly safety-conscious and convenience-oriented, and plans trail maintenance simultaneously considering the needs of logging and fire access as well as those of hikers. AMC, on the other hand, maintains trails for people who are in good shape and have appropriate gear.

Proponents of cooperative arrangements argue that these differences in perspective are desirable because nonprofit involvement will ensure that services are most closely matched to user needs. This view assumes, of course, that a nonprofit can better discern the public interest than can a public agency. However, the narrowness of many nonprofits' role definitions contrasts sharply with the breadth of goals mandated for public agencies. For example, until recently, in hiring trail crews, the Forest Service acted not only to maintain trails, but also to provide job training and income maintenance by hiring unemployed youths in the YACC and YCC programs. The Forest Service may have sacrificed a certain level of quality in its trailwork, but presumably other social goals were advanced in its place.

Differing role perceptions may well lead to neglect of legitimate public sector interests. For example, when the MDEM contracted with the Hitchcock Center for the interpretive program at Robinson State Park, MDEM viewed the effort as a demonstration project in which volunteers would have helped with the program, and hopefully would have carried on with it in the future. But the Hitchcock Center saw itself largely as a support group for professional naturalists, hence they did not put a great deal of effort into developing local voluntary support for the project, and the programs were not carried out in succeeding years.

The bottom line is that even if nonprofits can provide public land management services creatively and cost-effectively, for many services they are not interested or not suitable. Given an interested nonprofit, the public agency must be careful to ensure that the service to be provided matches the agency's expectations for it. Hence, nonprofit-public sector cooperative agreements do not appear to be a panacea. Rather, they constitute one management tool possible in a select set of situations.

Problems With Cooperative Agreements

Coordination and Communication

Almost by definition, cooperative agreements require a great deal of public-nonprofit coordination and communication. Yet the two problems cited most frequently by the surveyed nonprofits were the lack of coordination between nonprofits and public agencies, and confusion over roles, responsibilities and expectations for projects. Many of the nonprofits that had experienced confusion over roles or responsibilities felt that their problems resulted from the lack of a clear initial understanding of goals and objectives at both field and administrative levels.

Various communications problems were evident throughout the case studies in my research. These problems suggest that simply because two parties enter into a service contract, there is no guarantee that they are talking about the same item. Many land management activities involve the provision of "soft" services, that is, those that are hard to define in terms of outputs. To be effective, such service provision requires extensive and on-going communication throughout the course of a project. To operate otherwise will doom even the best intentioned project.

Public Sector Procedures

Public agencies often operate under a set of procedures that may be overly constraining for a nonprofit. It is not unusual for public agencies to establish reporting systems to monitor a nonprofit's activities in order to have some control over the work under contract. From the nonprofit's perspective, such systems are "red tape" that waste valuable time and staff resources.

Other government procedures may similarly cause problems for nonprofits if they are established as conditions of agreements. Work rules that require overtime pay or that specify particular methods to be used may negate the advantages of nonprofit service provision. Conservely, by not requiring contractors to follow certain rules, public agencies may get into problems with their own workers. For example, to allow the Hitchcock Center staff to run the interpretive program at Robinson State Park, state employees had to be on hand after normal hours to open and close the gate. By asking public employees to change their work habits, public employee labor union contracts may be violated. At the extreme, unions may view the expanded use of nonprofit labor as a form of union-busting, since some agreements result in the substitution of low-paid or voluntary labor for civil service workers.

Nonprofit Stability

Nonprofits are often organizationally unstable. Their staffs and policy emphases tend to change direction more quickly than those of public agencies. One reason for this is that many non-profit organizations employ relatively young workers at low wages. These individuals are attracted to nonprofit work because of the intrinsic rewards associated with their efforts, and often move to other jobs or educational programs after one to two years. In addition, nonprofits are often staffed by volunteers and part-time workers whose commitment is by definition tangential.

This type of turnover in nonprofit staff can lead to problems with cooperative agreements. Constant turnover makes it difficult for public managers to assess the quality or reliability of a potential nonprofit contractor. Second, nonprofits may have to spend part of their project time recruiting staff. Third, high turnover can result in projects being dropped. In addition, such change can put off a public agency that has a mission to carry out. In contracting with a nonprofit, the agency is never completely sure who will be carrying out the contract. This situation is especially problematic when the contract provides seed money to establish a continuing service. If organizational continuity is not maintained, the seed money may not sprout at all.

Nonprofit Accountability

The relatively high levels of nonprofit staff turnover and the resulting variability in performance cause public agencies concern about controlling nonprofit efforts under cooperative agreements. Part of the problem is that a nonprofit is not accountable to the same groups that monitor a public agency's performance, yet the agency does not lose the overall responsibility for the service that the nonprofit is providing. In addition, the lack of a profit motive reduces the control a public agency has over a nonprofit contractor. Nonprofits are less likely than for-profit contractors to act in a certain way in order to get more business. Finally, nonprofit organizations often lack managerial expertise and resist the planning mindset that characterizes good program administration (Herzlinger 1977).

The lack of good management information for many nonprofits and the few incentives that promote nonprofit accountability make it particularly tough for a public agency to evaluate and monitor progress of a nonprofit operating under a cooperative agreement. Part of the problem lies in the difficulty of measuring nonprofit success. Measures of productivity used to evaluate either for-profit or public agency efforts are generally inappropriate. In the case of for-profit contractors, one normally would evaluate their financial statements. Yet the principal goal of nonprofits is service provision and not financial return. Measures of productivity that can be applied to public agency employees cannot necessarily be used to evaluate a nonprofit's staff. It is unrealistic and unfair, for example, to expect volunteers to generate products at the same rate as paid staff.

Nonprofit Capacity

Finally, if public agencies seek an expanded use of cooperative efforts, a critical question that must be answered is: Are there nonprofit organizations that are willing and able to get more involved in public land management activities? While my research indicates that most nonprofits would be willing to get more involved given a project of particular interest to them, few are actively seeking expanded involvement. There is the generalized concern that groups and volunteers are already busy, and that they have already been exploited as much as they can be. The problem is particularly severe in the center part of the United States where there are fewer existing nonprofits.

It is this question of nonprofit capacity that will have a major influence on the degree to which public land management functions can be turned over to voluntary, not-for-profit groups. There is no evidence that volunteerism is an untapped resource. Increasing unemployment may result in a population with more leisure time, but such a population will most likely be more concerned with survival than with charitable contributions of their time.

Building Successful Cooperative Agreements

The key to enhancing the success of a cooperative agreement is to maintain some public sector control over the relationship without sacrificing the advantages provided by the nonprofit. The public manager has some elements of control at his or her disposal, including careful selection of both the nonprofit contractor and the project, and deliberate management of the agreement. In choosing a nonprofit group, it is important to be certain that the central mission of the nonprofit closely matches the objectives of the project, and that the methods normally used by the group closely match the approaches to be employed in the project. In addition, the normal operating area of the nonprofit should include the region to be served by the project. A nonprofit organization involved in a cooperative agreement should also be fairly stable in terms of staff, objectives, finances, and leadership. Lastly, if volunteers are needed to have a successful project, it is important to be certain that the group is oriented towards using volunteers, not just paid staff, and that it has an active membership and the ability to recruit volunteers.

The success of cooperative working arrangements is also influenced by the type of service to be provided. At minimum, a project undertaken cooperatively must provide a nonprofit with specific incentives to participate, either by furthering the central mission of the group or by providing it with subsidiary benefits. In addition, a tangible product or service or one that is identified with a specific geographic area will be more effective at soliciting nonprofit and voluntary involvement. If volunteers are to be used as the dominant workforce for a project, a project that has a number of separable parts that can be given to people who come and go will have a greater probability of success. For projects that necessitate building local support, there may be a strategic advantage in nonprofit involvement. On the other hand, since an agency loses substantial control over service provision, a public manager should be cautious about using cooperative arrangements where important agency priorities are involved or significant damage to an agency's image or program can result from mismanagement.

Careful management can minimize many of the problems that tend to occur during cooperative efforts. Agreement on and understanding of objectives, approaches, and methods is necessary at both field and policy levels at the outset of a project. Such an understanding can be facilitated by the development of a written cooperative agreement that identifies project objectives and scope, methods to be used, task allocation by type of worker and organization, methods of interagency communication, schedules of meetings, deadlines, products, criteria for success, resources to be contributed by organization, and contact people. A single contact person responsible for the project should be designated in both nonprofit and public agency. If the project involves collaborative working arrangements, a logical breakdown of work should be developed such that related tasks are performed by one organization, minimizing the need for coordination. One innovative role that public agency staff can play is that of a facilitator, acting as grantsman, providing technical assistance, collecting a resource base, and coordinating voluntary activity. While cooperative relationships are not a limitless resource, they are a useful management tool when certain conditions are met and the agreements are carefully administered.

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Public-Private Partnerships For Land Conservation

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Introduction

It is not a well known fact among public land professionals, or nearly anyone else, that the private commitment to the protection of land is nearly as old as the nation's. A mere 19 years after Congress established Yellowstone National Park as a "pleasuring-ground for the benefit and enjoyment of the people," the Massachusetts Trustees of Public Reservations ("Public" was stricken from the name in 1954 to avoid confusion with government agencies) dedicated themselves in 1891 to securing lands so that "crowded populations . . . should not be deprived of opportunities of beholding beautiful natural scenery."[1] Although the Trustees quickly won a favorable reputation that inspired similar efforts in Great Britain and elsewhere, not many in the United States imitated their work until after World War II. Since the 1940s, however, the pressures of interstate highways and residential sprawl on the one hand, and the nascent environmental ethic on the other, have increased the number of private land trusts to about 500. With an unusual combination of entrepreneurial spirit and philanthropic appeals, trusts have protected well over three million acres of land (over half subsequently resold to public agency "partners")—a rather astonishing total just under the size of the state of Connecticut.[2]

Far and away the largest of these trusts is the well-known Nature Conservancy, with over 30 years of experience and nearly 2-million acres (810,000 ha) of protected land to its credit.[3] Many of the organizations listed in the 1981 *National Directory of Local Land Conservation Organizations*—the first publication of its kind—in contrast, are little more than repositories for the occasional charitable contribution of some local land parcel or easement.[4]

Between these two extremes, however, are a growing number of active, locally and regionally based trusts which aggressively seek out donations of land, especially partial interests (development rights, rights of way, etc.), and undertake innovative limited development schemes to enable them to make their operations self-sustaining. Using the tax benefits of nonprofit organization status and the resultant ability to receive charitable contributions of interests (including below market value "bargain sales"), land trusts of all sizes present an attractive supplement to the actions of government.[5] They protect lands of local, regional,

[1]Gordon Abbott, Jr., "Historic Origins," in Lincoln Institute of Land Policy, *Resource Papers*, National Consultation on Local Land Conservation, October 14–17, 1981.
[2]Allan Spader, *A Prospectus—Land Trust Exchange*, Boston, Mass., July 1982.
[3]Dorothy Behlen, "A History," in *The Nature Conservancy News*, Vol. 31, No. 4 (July/August 1981), p. 5; author's conversation with Sue E. Dodge, *TNC News* Editor, February 14, 1983.
[4]Allan Spader, *1981 National Directory, Local Land Conservation Organizations*, Boston, Mass., 1982.
[5]See generally, Philip M. Hoose, *Building An Ark*, (Island Press, 1981).

statewide, and even national significance in response to priorities and programs generated from grassroots supporters.

But it is important to recognize that, in some cases, these land trusts can be most effective when in partnership with various levels of government. The initial partnerships between land trusts and government conservation agencies were almost accidental. Of course, the simple provision of tax benefits for private conservation was itself a form of partnership. But the actual cooperation of trusts and agencies really began with the Land and Water Conservation Fund (LWCF) in the middle 1960s.[6] When this Fund suddenly increased federal and state agencies' financial wherewithal to purchase large chunks of historic, recreational, scenic, and open-space land, these agencies naturally sought private help when particularly valuable and threatened properties might be lost to development unless land trusts' ability to move more quickly than government in the private market was utilized. Moreover, subsequent purchase by public agencies of land thus acquired by trusts often resulted in substantial savings to some agencies, as trusts could make attractive deals not possible for negotiators statutorily bound to pay fair market value for acquisitions. As a result, conservation agencies at all governmental levels quickly became familiar with this "roll-over" technique and it had become a fairly common method of public land acquisition by the middle 1970s.

The availability of LWCF money in the 1970s did, however, tend to limit public-private partnerships to this fairly narrow "roll-over" function. Innovation was obviously not a necessity so long as generous appropriations for the LWCF were made regularly. But this necessity is obviously very much with us as LWCF funding has plummeted and budgetary stringency seems likely to be the normal state of affairs for at least the rest of this decade.

More is at stake here than simple adaptation to unpleasant fiscal realities. Politically, today's massive LWCF cutbacks strikingly illustrate the vulnerability and inherent impermanence of a conservation tactic that depends entirely on federal largess. To be strong, land conservation must in the future rest on a broader base. State and local, public and private experimentation could produce a variety of land protection techniques tailored to the needs of diverse situations, while developing the sort of grassroots conservation constituencies that purely centralized programs are ill-equipped to achieve.

Finally, there is a long term dimension to the question of decentralization that should be of concern to all conservationists. Nationally significant resources are best protected by the Federal government, but not all resources that it has protected are nationally significant. The recent assumption of Federal responsibility to protect, under Federal auspices, lands and resources of more regional and local interest has generally been welcomed by state and local conservation constituencies and (understandably) politicians, who are thereby relieved of the onerous tasks of providing either adequate funding or political capital to do the job themselves. The standard and certainly arguable defense for direct Federal protection has been that it is better to protect these resources by Federal means than to lose them entirely.

[6]Glenn Tiedt, "Reduced Public Funding and a New Role for Non-Profits," in Lincoln Institute, *Resource Papers* (note 1, above).

One weighty objection to this Federal role is that, given the tremendous cost of many of these new Federal units (the price tag for Santa Monica Mountains National Recreation Area alone may run to several hundred million dollars), the nation cannot realistically afford a policy to provide such protection equitably, in every part of the country. And on occasion, the choice of areas to protect has corresponded more with congressional influence than with considerations of equity or resource quality.[7]

But the fundamental point here is that establishment of a Federal area, even with ample funding, cannot solve regional land use problems. A genuine, widespread environmental ethic is likely to develop in this country only when issues of land use and growth are directly confronted by state and local governments and citizens, as in the Pinelands of New Jersey and Adirondacks of New York. Experience has shown that modest Federal technical and financial assistance generally will make these state and local participants equal to the task. If state and local responsibility for regional land use comes to the fore, then public-private partnerships can provide these newly-active participants with an important ingredient in the development of that environmental ethic.

Case Histories

The cases below were selected to illustrate the variety of conditions from which partnerships develop, of motivations they reflect, and of forms they assume. Some were initiated by public agencies and others by private land trusts. Not all were successful. But their diversity of origin, experience, and result offers revealing glimpses of the strengths and limitations of public-private partnerships in helping to meet today's land conservation needs.

Protection of the Appalachian Trail

The Appalachian Trail was created in the 1920s by volunteers of the Appalachian Trail Conference (ATC) working under the direction and through the inspiration of noted forester Benton MacKaye.[8] Although simple handshake agreements with landowners were adequate to secure the Trail's route for many decades, the recreational home boom of the 1960s threatened to push those Trail sections not on public land entirely onto roads. This threat led the ATC to convince Congress to designate the Trail as the first component of the National Scenic Trails System in 1968, and 10 years later to authorize a $90 million acquisition program by the National Park and Forest Services to protect those private sections of the trail route. While the Federal trail corridor purchase program protected 333.6 of the 619.4 miles designated for Federal action by August 1981, it soon encountered pockets of fierce local opposition to NPS "land grabs," as well as Federal budgetary stringencies. As the original 1981 target completion date slipped by, ATC

[7]See, e.g., National Park Service, "Urban Open Space," (Technical Report No. 1) in *National Urban Recreation Study,* Technical Reports Vol. I (Government Printing Office, 1978).
[8]See generally, National Park Service, *Appalachian Trail Comprehensive Plan,* (Government Printing Office, 1981).

and NPS officials began to fear that certain choice sections of the trail might be lost forever to housing developments if they were not quickly protected.

Several mid-sized land trusts—the Ottauquechee Regional Land Trust in Vermont, the Housatonic Valley Association in Connecticut, and the Southern Appalachian Highlands Conservancy in Georgia, to name only a few—had previously been active in "rolling over" acquisitions of trail corridor land to the Park Service. These trusts, and others like them along nearly the entire length of the trail, met with ATC and Park Service officials in July 1982 to plan for the private protection of critical and threatened trail lands where the Park Service appeared unable to act. Immediately prior to this workshop, which was held in Dingman's Ferry, Pennsylvania, the ATC itself decided to form its own land trust directly oriented towards the protection of vital trail corridor lands. The Dingman's Ferry workshop, then, explored particular roles for the new ATC land trust to play, and ways in which the other interested land trusts could take actions that complemented the ATC trust's efforts while furthering their own goals.

The principal conclusion reached at the workshop was that the ATC trust should itself be the focus of coordination between individual trusts where their operations happen to deal with Trail lands, and the Park Service in its ongoing acquisition program.[9] A critical factor identified in both coordination and acquisition was the presence of a private trust (here the ATC Land Trust) that had trail protection as its primary, not a peripheral, mission. The magnitude of the task, participants agreed, required ultimate government responsibility for protection of the entire Trail corridor, as it had been assigned in 1968. But this left to the ATC and other land trusts an even greater task: protection, by easements, cooperative agreements, rights of way, and the like, of much of the area adjoining the Trail corridor. In other words, while the trusts recognized their fiscal limitations given the urgency of the immediate job at hand, they did not shrink from contemplating—indeed, they suggested—a far broader future protection role for themselves to complement that of the public agencies.

The result was thus neither a shirking of private responsibilities nor an over-optimistic assessment of private capabilities, but was instead a realistic but ambitious assignment of roles based on functional appropriateness and ability to carry them out.

Massachusetts Farmland Preservation

Our farmland is disappearing into other uses, often permanently, at the rate of approximately 3-million acres (1.2-million ha) per year. Despite controversy about the seriousness and full implications of this trend, many observers agree that some degree of action is needed now, if only to preserve our options while analysis of the conversion phenomenon continues. In certain regions, such as New England, the problem is particularly apparent. Massachusetts' dependence on outside agricultural production was perceived at a time when the decline in Commonwealth farming had reached truly alarming proportions: from 35,000 farms covering 2-

[9]Appalachian Trail Conference, *Proceedings, Appalachian Trail Land Trust Workshop,* July 22–23, 1982, pp. 2–3.

million acres (810,000 ha) in 1940 to only 5,900 farms on 679,000 acres (274,995 ha) in 1978, with only 311,000 acres (125,955 ha) of actual cropland in production on the latter date.[10] In response to this decline, the state legislature in 1977 enacted legislation to authorize state purchase of development rights on farmlands in order to protect their agricultural capacities. This politically popular program had, by June 30, 1982, expended nearly $10 million (only about 4% of that in administrative costs) to purchase restrictions on nearly 5,600 acres (2,268 ha) of farmland in the Commonwealth.[11]

One serious shortcoming in the Massachusetts program was its authorization to purchase easements only. Not only is it difficult for a public agency to respond quickly when a critically located piece of farmland comes on the market, but rarely in such instances is even a sympathetic seller interested in selling only farmland development rights and in seeking out a separate buyer for the farming rights. In July 1980, the venerable Massachusetts Trustees of Reservations stepped into the gap, establishing the Massachusetts Farm and Conservation Lands Trust (MFCLT). The MFCLT was thus founded expressly as a partnership to do what neither the private land market nor the Massachusetts Department of Food and Agriculture (DFA) were capable of doing effectively. By early 1983 the MFCLT had completed or signed contracts on twelve projects, protecting 1,007 acres (408 ha) of farmland. All purchase and about half of administrative costs were recovered by resale of development rights to the DFA, and of the farming rights to eager and skilled purchasers who would have been unable to acquire farmland on their own.[12]

The Massachusetts state program had approximately half of its $20 million funding authorization remaining at the end of FY 1982. Success and popularity make this program a likely candidate for continued authorizations in the future. As the program gains greater visibility and facility in operation, thus increasing the number of willing sellers, it is also likely that the importance of the MFCLT's role will increase. Attempting to adapt to the changing needs of farmland protection in Massachusetts, the MFCLT is building up a revolving fund of voluntarily donated and bargain sale easements to leverage future purchases.

The Massachusetts Farm and Conservation Lands Trust provides an impressive yet straightforward example of the potential for private, non-profit conservation organizations to identify and fulfill a specific, unaddressed need left by a public program. Partnership success has resulted, again, from close attention to the functional capabilities of public and private participants in addressing the requirements of the specific situation.

Fortesque Glades Wildlife Refuge

Not always do partnerships arise from the initiating party's urgent need for some added help or flexibility in protecting a particularly endangered resource, as in the Appalachian Trail and Massachusetts farmland cases outlined above. The Fort-

[10]Massachusetts Farm and Conservation Lands Trust, "Background Information and Operating Procedures," and "Annual Report 1981," March 22, 1982.
[11]Massachusetts Department of Food and Agriculture, "Annual Report, Fiscal 1982," p. 6.
[12]MFCLT, "Annual Report 1981," author's conversation with Davis Cherington, MRCLT Executive Director, February 14, 1983.

esque Glades case illustrates a very different type of situation: where a private land trust, here the Philadelphia-based Natural Lands Trust (NLT), was itself fully capable of managing a wildlife refuge it owned, but sought a partnership with a public conservation agency expressly to develop a new type of management-ownership partnership.

The land involved, a 4,000 acre (1,620 ha) tidal/estuarine wetland on New Jersey's northeast shores of Delaware Bay, was acquired by the NLT by purchase and bargain sale in various stages since 1964.[13] Considering active management to be a duty of responsible land stewardship, the NLT quickly built up a vigorous management program for the Refuge. The program included habitat improvement, trail development, educational activities and patrolling of the Refuge by boat, foot, and motor vehicle by a resident supervisor. Thus, when the NLT invited a public wildlife agency to acquire easements from it over the Refuge and to aid in preparation of a joint management plan, it was not because of the Trust's own inability to perform these functions. The larger aim was to engage the public agency in the planning for and in a secondary share of the ultimate protection of the resource, without demanding any continuing public expenditures for operations and maintenance. The project would be a model for the sharing of management responsibilities in significant resource areas.

Current public budgetary conditions may indeed "warrant an examination of possible new ways and methods to accomplish wetland preservation," as NLT president Andrew Johnson stated to a Senate Energy and Natural Resources Subcommittee workshop last year.[14] Ironically, those same conditions contributed to the NLT's failure to get its partnership idea implemented. Most public conservation agencies are not generally interested in purchasing easements, especially in a situation where they do not obtain new management responsibilities. But new responsibilities also imply new, continuing expenses. It is exactly the incidence of later management costs that causes budget problems for many public areas, as the National Park Service has found.[15] The interest of the Fortesque Glades Refuge concept lies in its ability to place many of those costs in the private sector, while retaining a government role in area management.

Admittedly, in this case the state and Federal wildlife agencies' rejection of the proposal was due in part to the paucity of land protection funds for any purpose, let alone one that seemed already to be adequately treated by a private organization. This reason for opposition is likely to continue even under less constrained budgetary conditions. Perhaps if the lands to be protected were identified jointly by the private land trust and public agency involved (as in the Massachusetts farmland example, above), before any land was actually acquired, public agencies' interest in the concept might be greater.

[13]Natural Lands Trust, *The Use and Protection of Privately Held Natural Lands,* (Philadelphia, October 1982), pp. 28–29.

[14]U.S. Senate Committee on Energy and Natural Resources, *Workshop on Public Land Acquisition and Alternatives,* Publication No. 97-34 (Government Printing Office, 1981), pp. 630–638.

[15]See, e.g., generally, General Accounting Office, *Facilities in Many National Parks and Forests Do Not Meet Health and Safety Standards,* CED-80-115 (Government Printing Office, 1980), and National Park Service, "State of the Parks, 1980 Report to the Congress."

California State Coastal Conservancy

California's State Coastal Conservancy's Land Trust Assistance Program deserves to be the final case study discussed here, for it combines many of the innovations and issues discussed above.[16] Apart from the philosophical bent towards localized, citizen-initiated conservation action, the Coastal Conservancy's immediate spur to create the Program was the mounting coastal accessways problem. The (regulatory) California Coastal Commission had, under its 1976 organic act, been requiring that developers dedicate coastal accessways to the public as a condition of granting building permits in the coastal zone. Fearing the cost of operating and maintaining these accessways, local governments had refused to accept more than one-third of the 580 accessways dedicated by 1981.[17]

As the failure to accept these dedications threatened the loss of public coastal access that was to have been a *quid pro quo* for new coastal development, the Coastal Conservancy responded by designing a program of reimbursable grants and technical assistance to coastal area land trusts and service groups to enable them to maintain the accessways and thus win acceptance of accessway dedication from local governments. Thus, the Assistance Program originated in the state Conservancy's need to enlist local support to carry out the Coastal Commission's regulatory mandate. Program design was based on the Conservancy's successful Humboldt North Coast experience, in which its $100,000 grant to a local land trust protected nearly as much land as the $1.3 million state park authorization that the grant replaced.[18]

As thinking for the coastal accessway assistance program progressed, it was broadened to include the full range of coastal conservation issues: wetlands, agricultural lands, lot consolidation problems, and a special program for Big Sur, as well as the public access element. The intention was to "let a thousand flowers bloom" by spreading front-end seed grants for specific projects in the aforementioned categories among local non-profit groups, who would thereby be far better equipped to carry on further coastal protection work themselves.

Grants were to be made largely reimbursable to encourage the ultimate financial self-sufficiency of the assisted groups. This would better equip them organizationally, both as political constituencies to support the Coastal Conservancy, and as local conservation groups which can continue to work regardless of the fate of either the Coastal Conservancy or the Land Trust Assistance Program. Grant reimbursement would, in turn, permit the Coastal Conservancy to create an Assistance Program revolving fund, enabling further seed grants to be made even if future state program appropriations are wiped out.

The wisdom of this approach may be illustrated even sooner than its originators intended. With last November's election of a Governor whose administration's opinion of the Land Trust Assistance Program is at best uncertain, the more than

[16]State Coastal Conservancy, ***Land Trust and Non-Profit Organization Assistance Program, Program Announcement and Grant Guidelines, Criteria and Procedure,*** January 1982.

[17]California Coastal Commission and State Coastal Conservancy, ***Innovative Management and Funding Techniques for Coastal Accessways,*** December 1980.

[18]State Coastal Conservancy, "Humboldt North Coast Land Trust, A Study of Investment Efficiency," in *The Coastal Community* (a periodical publication of the Conservancy), Vol. 1, No. 1 (February 1982), p. 1.

$1 million in grant funding expended by the Conservancy during FY 1982 alone appears even more timely and significant. Partnership here may prove to be beneficial for both the public and private entities involved, allowing them to pursue conservation goals despite the vagaries of the political climate.

Lessons From the Case Histories

In assessing the case histories and the commonalities among them, one principle is clearly paramount, if perhaps unsurprising: mutuality of interest. In each case described above, and in others as well, partnership success is largely attributable to observance of this principle; failure, or the requirement of substantial modification of a partnership *en route,* to its neglect. The initial, motivating factor in all of these partnerships was the initiating party's desire to pursue a conservation goal which it, by definition or circumstance, knew that it was not equipped to reach unaided.

Ironically, increasing controversy over the original public-private partnerships, land acquisition "roll-overs" to public agencies, has also emphasized the mutuality principle. A 1981 report by the General Accounting Office (GAO) suggested that government agencies develop criteria to govern their "roll-over" dealings with land trusts.[19] The Interior Department has since proposed a pre-acquisition, two party statement of intent regarding the land interest to be acquired, its estimated value, and the projected time frame for acquisition, to meet the GAO recommendation.[20] Most private trusts support this proposal; a very few oppose it. If the partnership concept means anything, surely it implies that private trusts cannot simply choose their "roll-over" transactions at pleasure and then demand that the Federal government incorporate those transactions into their budgetary priorities. A mutually beneficial partnership loses its value when a refusal to communicate and coordinate adequately forces one or both partners to take adversarial positions.

A second, corollary principle demonstrated in the case histories is that the availability of an adequately funded agency program is a prerequisite for successful partnerships. While the funding required by partnerships is likely to be much lower than under agency fee purchase programs, some reasonable amount of funding is still essential, as the Fortesque Glades project showed. LWCF cutbacks thus may stimulate new partnerships, but the latter will not flourish unless the Federal government rescinds some of the former. Conversely, each land trust has the obligation to frame its partnership proposal in terms acceptable to some conservation entity in the government addressed by the proposal.

As with any well-devised policy initiative, specific partnerships must fit the organizational, political, social, and economic setting they are intended to address; but that setting will be more demanding for a land trust with an idea to sell than for an agency with appropriations to offer. By choosing a strategy before it had even identified a partner, the Natural Lands Trust ran afoul of the mutuality principle; failing to identify a government program supporting its partnership goals, the NLT could get no funding. In contrast, the public California Coastal Conser-

[19]General Accounting Office, *Overview of Federal Land Acquisition and Management Practices,* CED-81-135 (Government Printing Office, 1981).
[20]47 Federal Register 38431 (Tuesday, August 31, 1982).

vancy's Land Trust Assistance Program and the private Massachusetts Farm and Conservation Land Trust's mission were specifically designed around the characteristic strengths and shortcomings of the initiators' prospective partners. Observance of the mutuality and funding principles may mean that in some cases no partnership can be developed. Alternatively, as in the case of the Appalachian Trail, the partnership concept was changed (because of land trusts' desires expressed at the Dingman's Ferry workshop) from one where the Park Service would work actively and directly with a large number of trusts to one where NPS would tend to rely on the ATC's Land Trust as a coordinator of and liaison with private trust activities in and around the Appalachian Trail corridor.

Within the foregoing limitations imposed by the mutuality and funding principles, new partnerships can be adapted to a variety of conditions and policies. Obviously, specific program goals and clear program processes will further increase the likelihood of partnership success (on this point, compare the Massachusetts Farm and Conservation Land Trust's experience with that of the Natural Lands Trust). But comparatively broad goals can also be accommodated in successful partnerships (e.g., the California State Coastal Conservancy and the ATC). Whether the initiating party is in the public or private sector seems to be largely irrelevant, so long as that party is realistic about its capabilities and those of its proposed partner. Thus, if the mutuality and funding principles are observed, the potential for innovative and effective land conservation partnerships is subject only to imagination and willingness to experiment. One particularly intriguing example will illustrate the point.

New Directions in Conservation Partnerships

The French system of regional natural parks, though little known in the U.S., deserves study here, for it evidences a sophisticated understanding of cultural landscape dynamics. Most important for purposes of this discussion, the French regional parks system suggests a point of departure for the design of a vigorous and exciting new role for partnerships in rural conservation.

Regional parks have been established in about 20 remote, scenic areas spread throughout the country, areas where, in the words of Joseph L. Sax, "isolation, rugged landscapes, small-scale agriculture, and traditionalism . . . made these places economic disaster areas."[21] While moderate land use regulations are enforced to prevent development that is out of scale or spirit with regional character, the parks' distinctive feature is a program of government assistance to further low-intensity, "cultural tourism" focusing on each region's unique patterns of interaction between inhabitants and the landscape. Strategically targeted funds go to support indigenous crafts and agricultural activities, provision of "gites" (simple rural lodgings), traditional cultural festivals, and so forth. For example, grants to farmers in the Armorique Park of west-central Brittany encourage adherence to age-old practices of pig-raising and pork, ham, and sausage production, the latter activities often in conjunction with lucrative local fairs. These activities, and similar

[21]Joseph L. Sax, "In Search of Past Harmony," in *Natural History*, Vol. 91, No. 5, (August 1982), pp. 42–51, 77.

ones maintained through the regional parks, are key factors in shaping both the landscapes and the lives of their inhabitants. Most fundamentally, the very concept of these regional parks reflects the recognition that protection of landscapes whose attractions derive in part from their human contributions depends as much on economic vitality as on land use control.

Here in the U.S., fear of a government role in distributing this type of aid could be avoided by resort to locally-based land trusts, which could have both the awareness of local concerns and the responsiveness to local needs required for such an assistance program to succeed. If government funds were channeled through land trusts under guidelines designed only to prevent abuse, those trusts could greatly strengthen their bases of support in and their understanding of their constituent communities and regions. In any case, without the vibrant and economically viable communities which helped create our important cultural landscapes in the first place (e.g., New England or southern Pennsylvania hill farms), these landscapes could become beautiful but empty shells even if they are "protected." While the immediate political environment for such an initiative from Washington is dismal, the demand for cost-effective, "unobtrusive" conservation measures will return with a revived sense of governmental responsibility for positive conservation action.

Wildlife Research by Private Conservation Organizations: Contributions and Opportunities

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A special session on fish and wildlife research needs was featured at the 44th North American Wildlife and Natural Resources Conference (Sabol 1979). That session reviewed the roles of state and federal agencies and universities in conducting wildlife research, but largely omitted the research contributions of private industry and private conservation organizations (PCO's) (Burger and Labisky 1979). It is appropriate in this session on emerging nonfederal research initiatives in resource management to review the research contributions of PCO's. Private support of wildlife research is not a recent phenomenon, as evidenced by such projects as the Cooperative Quail Investigation of 1924–29 (Stoddard 1931) and the Game Survey of the North Central states of 1928–29 (Lepold 1931). Also, Stahr and Callison (1978) briefly mentioned research in summarizing the role of private organizations in the wildlife conservation field.

Research endeavors of PCO's are only a fraction of the size of state and federal programs, but they have made significant research contributions. In some areas like research and management of nongame species, PCO's have clearly led the way (Callison 1974). PCO's will never replace state, federal, and university research programs but, by focusing on areas underfunded in these programs they can complement existing state and federal research efforts. Research in the areas of endangered species, nongame wildlife, urban wildlife, and wildlife policy are among the targets for PCO's.

During the past year decreases in the availability of federal funds has also impacted federal, state, university and cooperative research programs. In this paper we discuss how the contributions of PCO-conducted research can help minimize losses in federal funding and examine the opportunities for cooperative research activities between PCO's and other research groups.

The data presented are based upon the personal experience of the authors in federal, state, university, and private programs, a literature review, and the responses

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to a questionnaire (Appendix I) sent to a representative sample of PCO's (Appendix II).

Profile of PCO's

PCO's do not think and operate in unison. They are as pluralistic as society itself. Some groups like Save the Redwoods League or the Whooping Crane Conservation Association, Inc. focus their conservation efforts on a particular species; others like Ducks Unlimited and the Urban Wildlife Research Center, Inc. are concerned with broader resource areas, and still other organizations like the National Wildlife Federation and the National Audubon Society have very broad environmental programs. Despite differences in approach, PCO's have one common objective and that is enhancing natural-resource conservation.

The 1983 *Conservation Directory* published by the National Wildlife Federation lists 392 associations, councils, foundations, federations, institutes, and societies. There are hundreds of regional, state, and local organizations that were not on that list. No attempt is made to summarize the research activities of each PCO in this paper. However, we have cited examples of programs to illustrate the research contributions of this segment of the natural resource community.

Sources of Funding

Since PCO's function under the same economic conditions as state, federal, and university programs, they too are affected by the state of the economy. Federal wildlife research programs are largely funded from annual budget appropriations and states from a combination of hunting and fishing revenues, federal "pass-through" funds, and some state legislature appropriations. PCO's depend upon some combination of membership dues, corporation or foundation grants, endowments, direct mail solicitation, special project fundraising campaigns, sales of merchandise or publications, and some state and federal contracts to fund their programs. The special status of many of the larger PCO's under Section 501(c)3 of the Internal Revenue Code helps in their fundraising efforts (Stahr and Callison 1978). This status allows contributors a tax deduction on donations to many PCO's. This mechanism for funding PCO's encourages individuals, corporations, and foundations to provide financial and volunteer support which they would not ordinarily offer to governmental agencies. A few PCO's like the Welder Wildlife Foundation rely upon interest on investments, oil royalties, and livestock sales to fund their research programs.

Twenty-two of the 30 respondents to our questionnaire indicated that they had wildlife research programs and that membership dues and special issue fundraising were their principal sources of research funds, followed by grants from corporations and foundations. By developing a variety of income sources the PCO's generally maintain a relatively constant level of research funds. Annual research budgets for nine of the PCO's queried were greater than $100,000 per year.

Research Programs

Setting Priorities

Federal resource agencies formulate their research programs in response to needs identified in federal laws dealing with natural resources (Loveless et al.

1979). State conservation departments are required by state law to protect and manage resident wildlife species, and they develop their research programs accordingly.

PCO's have much greater flexibility and independence in establishing and changing their research goals than either state or federal agencies. Frequently, PCO's concentrate their research efforts on an area that is underfunded at the state and federal levels. This type of gap-filling thus complements existing governmental programs.

The objectives or goals of most PCO's are stated in the bylaws of the organization. These objectives can be interpreted more broadly and revised more readily than an existing state or federal environmental law. Those organizations responding to our questionnaire indicated that inhouse priority setting was their principal method of selecting research topics. This was followed by response to a demonstrated need in a particular resource area, board recommendations, and funding availability for a particular project.

We do not wish to imply that single purpose PCO's are necessarily more efficient than the multiple objective conservation organizations. However, it would seem that, with proper management, a PCO with a single, well defined research objective could accomplish more with limited resources than one engaged in a broad multifaceted research program. For example, Tall Timbers Research, Inc., while concerned with many aspects of wildlife habitat and public education has focused on fire ecology since its founding in 1958. The founders of Tall Timbers reasoned that, to understand the environmental effects of fire and the use of fire in habitat management, there must be continuity of research over a long period of time—100 years or more (Komarek 1977).

Other examples of largely single-purpose PCO's may be cited. The Artic Institute of North America is dedicated to the acquisition, interpretation, and dissemination of knowledge of polar regions. The Bass Research Foundation promotes applied research on America's bass fishery resources. The Bear Biology Association helps coordinate bear research and management. The Desert Bighorn Council promotes the advancement of knowledge concerning desert bighorn sheep. To enhance their contributions, these PCO's need to cooperate with and coordinate their programs with those of other PCO's, universities, and government agencies involved in wildlife research. The majority of the PCO's indicated that they conducted their research programs with inhouse staff. Others contracted with universities or consultants to complete a particular research project. The number of employees with advanced degrees in biology ranged from zero in some of the smaller PCO's to 35 in a large organization like the American Museum of Natural History. Nongame and endangered species research were reported as the most common PCO research programs, followed by studies of game species and wildlife policy.

PCO's were asked to list the advantages of conducting research through a private organization compared to a state or federal agency. In summary, they believe that first, PCO's make more efficient use of funds due to fewer levels of bureaucracy, less red tape, and lower overhead charges; secondly, research is less affected by major changes in policy; in other words, studies are based on merit instead of politics; thirdly, research is conducted in areas traditionally not covered by state and federal programs; and fourth, PCO's have a faster response time to a demonstrated need which again relates to greater efficiency.

Examples of PCO Research

The efforts by the National Audubon Society to reestablish seabird colonies, the National Wildlife Federations's midwinter bald eagle survey and eagle banding program, the Urban Wildlife Research Center's urban wetland study, and many of the research projects funded by the American Museum of Natural History are examples of PCO nongame research. The programs of the New York Zoological Society, through its Animal Research and Conservation Center, deal with a broad array of rare or endangered species like the giant panda in China and the Andean Condor in Peru. The red data books of the World Wildlife Fund and their studies of Neotropical migratory birds are additional examples of PCO endangered species related research. A number of PCO's concentrate on game species, although their programs frequently include other types of research. The research programs of the Delta Waterfowl Research Station in Manitoba, Remington Farms in Maryland, and the Welder Wildlife Foundation in Texas are involved with a variety of game and nongame species.

One area of research that is perhaps unique to PCO's is wildlife policy research. This type of research provides a public interest oversight of state and federal wildlife programs. The Wilderness Society, the National Wildlife Federation, American Wilderness Alliance and the Izaak Walton League have wildlife policy research programs. Several of the PCO's like the Wildlife Society, the Wildlife Management Institute, the International Association of Fish and Wildlife Agencies, and the American Society of Mammalogists support wildlife research by promoting and often funding the research efforts of their members and supporters.

In addition to conducting their own research programs, many PCO's offer scholarships or fellowships to students studying in the biological sciences. The Environmental Conservation Fellowship Program of the National Wildlife Federation has given awards amounting to $1,000,000 to 635 students since 1956. The Theodore Roosevelt Fund of the American Museum of Natural History has provided research funds for a variety of wildlife research topics. Some PCO's also offer a three to six month internship program to provide valuable on-the-job training to students pursuing a career in wildlife conservation.

The research results are most frequently reported in journal articles and press releases according to those PCO's responding to our questionnaire. Newsletters, workshops and symposia, and subscription magazines also were frequently listed as publication outlets.

PCO's research contributions have frequently augmented existing state, federal, or university programs. In spite of their past contributions, there are clearly limitations to the amount of work that can be conducted by PCO's.

Limitations

The most severe limitations facing PCO's in their efforts to conduct wildlife research lie in the areas of funding, management, and programming. Respondents to our questionnaire listed financial limitations and associated facility and personnel limitations as the most serious problem.

Funding

No matter how thoroughly planned or how great the need, a research program cannot succeed without an adequate level of funding. Reviewing the causes of failure for many inland biological stations (and we believe it applies to PCO research programs as well) Komarek (1977) concluded that poor fiscal planning was a frequent reason for an "early death." He stated (p. 5), "A continuous, fairly stable yearly income must be maintained. This cannot be done solely by grants or contributions from either individuals or governmental agencies or foundations. The basic monies must come from well-protected and well managed endowments."

In order to tap the list of potential funding sources previously mentioned, a PCO must write each research proposal somewhat differently to appeal to each of these sources.

In order to obtain corporate funding successfully, proposals must appeal to the businessperson. In other words, corporations give because it is good business. The PCO must demonstrate to the businessperson that his company stands to benefit from supporting the PCO's cause. This usually means a non-confrontational approach. It can be argued that conservationists and industry must work more closely together to accomplish environmental goals.

Foundation funding is increasingly more difficult to secure. Many organizations fail to obtain foundation grants because of a lack of understanding of how to make a proposal appeal to a foundation. It is extremely important that the foundation be thoroughly researched to determine its specific area of interest before preparing a proposal. Such information may be obtained from organizations such as the Foundation Center located in Washington, D.C. However, the importance of having the proper communication channels to foundation board members or executives cannot be over-emphasized. Ideally, the PCO employs an executive or development director who has personal contacts in the foundation area. If this is not done, PCO Board members must be relied on more heavily for their assistance in getting in the door.

Government funding also is becoming more difficult to obtain. Many a PCO is struggling due to the loss of government grants and contracts resulting from the current economic situation and general trend toward reduced government spending. However, government agencies will continue to have a need for research and, with reduced manpower, probably will have to go to outside organizations to accomplish the work. Much of this work will go to universities, but qualified PCO's should be alert to potential opportunities, especially in the area of nongame and urban wildlife research.

Membership dues provide a substantial amount of funding to support programs of PCO's. However, members usually must receive substantial benefits from the organization in order to maintain interest. There is a tremendous amount of competition for the general membership dollar among conservation organizations, and a fairly sophisticated and expensive approach using the direct mail is required to reach potential members. It should be noted that the general public may be unaware of the importance of wildlife research and appeals must necessarily be directed toward a pressing need or controversial topic to elicit an acceptable response. Often, the research-directed organization is not oriented to such appeals and must seek counsel of consultants to prepare effective materials. The material prepared sometimes may be unpalatable to some members of an organization or not in accord with a scientific approach, but if the organization wishes to pursue general membership as a funding source, this may be necessary.

Individual large donors can be an asset to a PCO. These people often give to a cause they strongly believe in and can be convinced to support research programs on a continuing basis, but they require careful personal cultivation in order to capture and maintain their interest.

Management

PCO's normally are operated by a staff under the general guidance of a Board of Directors or Trustees. The Board is responsible for providing policy direction and is ultimately held legally liable for the proper functioning of the organization. The make-up of the Board is critical to the success of the PCO. Ideally, board members should be selected because of their wisdom, wealth, or willingness to work. The PCO staff must depend on the Board to provide guidance on research priorities and sources of funding.

The day to day operations and successful implementation of programs must be the responsibility of professional personnel. It is critical that competent and dedicated personnel be placed in executive and administrative positions and be allowed by the Board to pursue programs. It also is extremely important that sufficient resources (technical support staff and financial) be allocated to carry out their research responsibilities effectively. The staff must help motivate the Board to accomplish goals. Many PCO's are less effective than they could be as a result of poor staff-Board communications.

Communication must be maintained with the membership through regular periodic publications. A newsletter can be used very effectively but should be prepared at least on a quarterly basis. It is important that the membership be informed of current activities and accomplishments of the PCO and be provided with an opportunity to contribute if they wish. Members must feel that they are a part of the organization and should receive careful attention. The staff must be sensitive to the opinions of the membership and should periodically poll the members to determine their attitudes and positions on important questions of policy.

Volunteer members can be a tremendous asset to a PCO. In professional societies, the membership is the heart and soul of the organization. It is therefore extremely important to stay in touch with the membership's concerns.

Programming Problems

PCO's tend by necessity to focus on short-term projects. This is often because the funder demands immediate results. There is a serious need for more long-term research projects, and PCO's should make every effort to secure support for such studies. Foundations seem to have the most potential for supporting long-term studies because they function more independently and solely for philanthropic reasons. Larger PCO's have a responsibility to devote a greater portion of revenue to research. Five percent of gross revenues is a reasonable amount to allocate, but most PCO's, even the large national groups, spend closer to one percent. To rectify this, top management must make a commitment to support research.

There is a tendency for PCO's to focus their research programs on emotional, glamorous, or parochial issues. This is understandable as these types of issues are of more immediate concern to the membership. However, it is incumbent upon conservation organizations to address environmental issues on a holistic basis, with less emphasis on areas of special interest. Using this approach, PCO's can more effectively address the important conservation research issues of the future.

Opportunities

With the plethora of universities, federal and state agencies, and industrial or commercial firms engaged in research on wildlife, wildlife habitats, and other environmental problems, it might appear that there is little need or justification for PCO research. On the contrary, opportunities abound for research in areas ranging from the more traditional game-oriented projects to in-depth wildlife policy research. The list of potential programs provided in response to our questionnaire indicated that a commitment to long term research projects was believed to be one of the greatest opportunities for PCO's. Other recommendations included expansion of the PCO gap-filling role to further complement state and federal programs and increased work in the area of wildlife policy. Because of their broad public constituency, PCO's have an excellent opportunity to see that the results of their research are applied in state and federal planning and management programs.

Promotion of Research

Private organizations need not have extensive inhouse research programs to advance wildlife research. They can advise and encourage government agencies to conduct the type of research they consider desirable. Through selective funding of graduate students or possibly other more research-oriented PCO's, they can promote research along a given course. The Wildlife Management Institute, in addition to supporting research at the Delta Waterfowl Station in Manitoba, has contributed importantly to the nationwide Cooperative Research Unit program both through funding and guidance. Their sponsorship of the North American Wildlife and Natural Resource Conferences and the related meetings held in conjunction with these conferences has been a boon to wildlife research and the dissemination of research results.

PCO's can serve as information clearinghouse centers for different areas of research. This function not only facilitates communication among researchers, but also helps to prevent needless duplication of research effort. Along this same line, PCO's can expedite the use of research results in management decisions through their existing educational and lobbying programs.

Demonstration Areas

Following the example of the extent programs of the Department of Agriculture, PCO's have the capability to develop areas that demonstrate sound management practices not only for game but for nongame wildlife as well. There are examples of this type of program already in existence among PCO's.

Remington Farms, operated by the Remington Arms Co., Inc. since 1956, has shown that some types of farming and wildlife are compatible. It has also served as a demonstration for good soil conservation practices. The National Audubon Society, through its sanctuary management program, has demonstrated habitat management practices for many nongame birds. Their wetland walkways, like the type developed for Corkscrew Sanctuary in Florida, have served as models for other areas.

There is a definite need for research to develop other types of demonstration areas that show how people and wildlife can coexist.

Research on Conservation's "No-man's Land"

Traditionally, wildlife habitat has been regarded as forests, farms, ranches, rangelands, parks, refuges, and other rural or wilderness areas. There are enormous acreages of other areas, such as highway and utility rights-of-way and urban and subruban property, that also provide wildlife habitat.

Approximately 1-million acres (404,859 ha) of agricultural land are converted to urban uses each year in the United States. There is an urgent need for research information to help with planning and managing urban areas for fish and wildlife. Most of our population live in cities, suburbs, and villages, and many of these city dwellers have little opportunity to view wildlife, become aquainted with the workings of natural phenomena, or become knowledgeable about the concepts of conservation. Yet urban residents, because of sheer numbers and votes, can have an important role in environmental legislation and conservation affairs in the wilderness as well as in urban areas.

Another largely neglected area of wildlife research is that of rights-of-way (ROW's). Asplundh Environmental Services (1979) estimated that there are 34,153,010 acres (13,832,000 ha) of ROW's in the United States, an area about the size of the state of Arkansas. This area is apportioned as follows: highways, 23,258,575 acres (9,419,723 ha); electric utilities, 5,104,556 acres (2,067,345 ha); and railroads, 2,408,980 acres (975,637 ha). When surface-mined areas are added, the total acreage is substantial and represents abundant opportunities for research.

Conclusions

Private conservation organizations have made and will continue to make significant contributions to man's understanding of the environment through wildlife research. Their programs are much smaller than those of state and federal agencies, but they frequently complement existing larger programs.

These organizations serve a valuable oversight function to ensure that our Nation's research efforts address a broad array of wildlife species and topics. In recent years, PCO's have concentrated their research in the areas of wildlife policy, endangered and nongame wildlife studies, and people-wildlife interactions. Although many PCO's conduct research on game, most have expanded their efforts to look also at nongame wildlife.

The lack of a dependable and predictable base of financial support is the most serious limitation to their research programs. A tendency to focus on highly controversial issues to generate research funds is inconsistent with more objective procedures for setting research priorities. The greatest strength lies in the institutional commitment to the conservation of natural resources and a subsequent continuity of purpose.

There are abundant opportunities for PCO's to coordinate and cooperate with state, federal, and university programs. Opportunities to take a leadership role exist in research and management of rights-of-way and other miscellaneous areas, development of demonstration areas, and the promotion of information transfer among researchers and the public. PCO's have a unique opportunity and obligation to use their broad public support to ensure that recommendations from all types of sound biological research get implemented into resource decisions.

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Appendix I

Questionnaire sent to 62 Private Conservation Organizations.

NAME (of preparer)
TITLE
ORGANIZATION
ADDRESS ZIP CODE
PHONE NUMBER

1. Does your organization engage in wildlife research? Yes _____ No _____

2. Which category listed below best describes the type of research of your organization? (circle selection(s))
   a. Wildlife Policy
   b. Endangered Species
   c. Nongame Wildlife
   d. Urban Wildlife
   e. Game Species
   f. Management
   g. Environmental Contaminants
   h. Animal Control
   i. Other

3. Approximately how much money does your organization spend annually on wildlife research?
   (circle selection)
   a. < 10,000
   b. 10,001 - 20,000
   c. 20,001 - 30,000
   d. 30,001 - 40,000

e. > 50,000 f. > 100,000

4. How does your organization conduct its wildlife research? (circle selection)
   a. "Inhouse" staff
   b. Contract with University
   c. Contract with Individual
   d. Contract with State agency
   e. Contract with federal agency
   f. Contract with other PCO

5. Does your organization employ research individuals holding advanced degrees in biology?
   Yes_____ No_____ If yes, how many, and what academic disciplines (e.g. zoology, ornithology, wildlife, etc.)?

6. Does your organization have a fellowship or scholarship program for students in the biological sciences? Yes_____ No_____ If yes, please describe (attach copy of program announcement).

7. Does your organization offer an intern program to qualified students in the biological sciences? Yes_____ No_____ If yes, please describe (attach copy of program announcement).

8. Does your organization have any formal cooperative research programs with:

State agencies	Yes _____	No _____
Federal agencies	Yes _____	No _____
Universities	Yes _____	No _____
Other PCO's	Yes _____	No _____

9. What is the principal source of funding for your research programs? (circle selection(s)).
   a. Federal grants/Contracts
   b. State grants/Contracts
   c. Foundation grants
   d. Membership dues
   e. Special project fund raising
   f. Corporation grants

10. How does your organization select its wildlife research projects? (circle selection(s))
    a. Availability of funds
    b. "Inhouse" priority setting
    c. Board recommendation
    d. Membership recommendation
    e. Demonstrated need
    f. Other

11. In your opinion, what are the advantage of conducting research through PCO's compared to state and federal agencies or universities? (attach additional sheet, if desired)

12. In your opinion, what are the disadvantages or limitations of conducting wildlife research through PCO's compared to state and federal agencies or universities?

13. List some examples of projects that your consider to be your organization's significant wildlife research contributions.

14. How does your organization inform the public of the results of your research programs? (circle selection(s))
    a. Newletter
    b. Subscription magazine
    c. Press release
    d. Seminar or workshop
    e. Publication in scientific journal
    f. Other

15. In your opinion, what are the major research opportunities and research roles for Private Conservation Organizations like yours?

Appendix II

List of Private Conservation Organizations that were sent questionnaires. Those marked with an asterisk responded, a double asterisk indicates that the organization has a wildlife research program.

American Forestry Association
*American Forest Institute
**American Museum of Natural History
American Petroleum Institute
**American Society of Mammalogists
American Society of Zoologists
**American Wilderness Alliance
Animal Protection Institute of America
**Animal Welfare Institute
**Arctic Institute of North America
Bass Anglers Sportsman Society
**Bass Research Foundation
*Bear Biology Association
**Boone and Crockett Club
Center for Environmental Education, Inc.
Center for Urban Environmental Studies
*Conservation and Research Foundation
*Conservation Foundation
J. N. "Ding" Darling Conservation Foundation
**Defenders of Wildlife
**Delta Waterfowl Research Station
Ducks Unlimited, Inc.
Elsa Wild Animal Appeal
Environmental Defense Fund, Inc.
Environmental Research Institute
*Federal Cartridge Corporation
Friends of Animals, Inc.
**Friends of the Earth Foundation, Inc.
Fund for Animals, Inc.
Game Conservation International
Humane Society of the United States
*International Association of Fish and Wildlife Agencies
**Izaak Walton League of America, Inc. (Policy Research)
John Muir Institute for Environmental Studies, Inc.
**Max McGraw Wildlife Foundation
**National Audubon Society
National Geographic Society
National Rifle Association of America
*National Shooting Sports Foundation, Inc.
National Trappers Association, Inc.
**National Wildlife Federation
**National Wild Turkey Federation, Inc.
Nature Conservancy
**New York Zoological Society
North American Wildlife Foundation
North American Wolf Society
Peregrine Fund, Inc.

Raptor Research Foundation, Inc.
**Remington Farms
*Resources for the Future
Ruffed Grouse Society
Safari Club International
Safari Club International Conservation Fund
Sierra Club
Sierra Club Foundation
**Urban Wildlife Research Center, Inc.
**Welder Wildlife Foundation
**Wilderness Society (Policy Research)
The Wildlife Legislative Fund of America and the Wildlife Conservation Fund of America
**Wildlife Management Institute
Winchester Group, Conservation Department
**World Wildlife Fund—U.S.

State-Supported Habitat Management and Commercial Hunting on Private Lands in the United States

James G. Teer
Welder Wildlife Foundation
Sinton, Texas

George V. Burger
Max McGraw Wildlife Foundation
Dundee, Illinois

Charles Y. Deknatel
Department of Community and Regional Planning
College of Architecture
University of Nebraska, Lincoln

In this paper we describe current efforts of the states to promote habitat protection, development, and management on private lands, and present a case for commercial hunting as the chief incentive for landowners to practice wildlife habitat management.

Of the total of about 2.4 billion acres (1 billion ha) in the United States, 71 percent, or about 1.7 billion acres (688.5 million ha) are in extensively managed forest lands, rangelands, and water areas (USDA Forest Service 1980). These huge areas are the most responsive to wildlife management because much of their character of natural vegetation, ecological diversity, and low disturbance by human activity is retained in extensive agricultural production systems. The remaining 700 million acres (283.5 million ha) are devoted primarily to valuable agricultural commodities, urban environments, and industrial and transportation systems. The practice of wildlife management on these very productive lands on the same scale as on extensively managed lands can be incursive and costly to those who own them and to the consumers who buy their products.

Much of what is presented has been said in our previous papers (Teer and Forrest 1968, Teer 1974, 1975, 1976, Deknatel 1979, and Burger and Teer 1981). However, we queried the states in late 1982 to determine the patterns and dimensions of state-supported habitat management. The results of this survey are useful for assessing current trends and for making predictions about the directions management of habitat and hunting will take on private lands.

The federal government through programs of the departments of Agriculture and Interior has had a number of habitat management programs to promote wildlife production on private lands for many years. These programs have traditionally taken the form of set-aside acreage through Soil Bank and Water Bank programs, and of direct payments for fee-simple title and easements for such critical habitat as wetlands in waterfowl production areas in the prairies.

The Wildlife Production Areas purchased in fee simple by the U.S. Fish and Wildlife Service with funds from the Migratory Bird Conservation Fund represent one of the largest efforts by the federal government in recent years. About 450,000 acres (182,250 ha) of wetlands have been purchased since 1961, largely in Minnesota, North Dakota, and South Dakota, for a total price of about $67,000,000 (U.S. Fish and Wildlife Service 1982).

Such purchases transfer ownership and obligation for management to government. We are interested today in management of wildlife on private lands by landowners and by those who use such lands.

State Supported Programs

State-sponsored programs typically have offered indirect or totally noneconomic incentives—signage, and other protection for tresspass, access control, technical advice, and plant materials (Burger and Teer 1981). We sent a brief questionnaire to state game and fish departments and received replies from all of them. Only 13 of the 50 had no type of wildlife habitat program. The remaining 37 reported they offered technical advice and assistance when requested. Many of the states did not report organized, budgeted, named projects; however, their biologists and managers provide the service as a part of their regular duties. The provision of technical advice and plant materials remains the most usual service provided by the states (Table 1).

The center of habitat management is in the farm and wetland areas of the mid-continent (Tables 2 and 3). Most of the 17 western states do not have budgets for purchases of habitat or for management of habitat on private lands. The obvious reason for the lack of programs in the West is that a great part of the 17 western states is federally owned, and few states have opted to put funds into management

Table 1. Habitat management programs supported by state funds in 1982.[a]

Activity	States
Provision of technical advice	AL, AR, CA, CO, CN, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, ME, MD, MI, MN, MO, MS, MT, NE, NH, NJ, NM, NY, NC, ND, OH, OK, OR, PA, RI, SC, SD, TN, TX, VT, WA, WI, WY.
Provision of plant materials	AR, CO, IA, IL, IN, KS, LA, MA, MD, MN, MO, NE, NC, OH, OR, PA, RI, TN, WI.
Provision of signage	CO, IL, IN, KS, MD, NC, NE, OH, OR, PA, RI, SD.
Provision of labor	CO, IA, IL, KS, LA, MN, MO, OR, PA, WI.
Conservation easements and tax credits	CO, HI, IA, IN, MD, MN, MT, NH, OR.
Cost-sharing with landowner and direct payments	CO, IA, IN, KS, KY, MD, MN, NE, ND, OH, OR, PA, SD, WI.
Agreements made with landowner to maintain practices	CO, IA, IL, IN, LA, MN, NE, ND, OH, OR, PA, RI, SD, WI.

[a]Every state that reported some type of habitat management provided technical assistance to landowners by visits to the field. Some of these states had extension personnel whose main job was to work with landowners in wildlife management activities.

Table 2. Number of cooperators and acreages in habitat management on private lands in 28 states.[a]

State	Program began	Number of participants in 1982	Acreage	(ha)	Trend increasing (+) or decreasing (−)
Arkansas	1972	2,524	868,400	(351,702)	+
California	1980	5	319,000	(129,195)	
Colorado	1975	49	1,815	(735)	
Florida	1979	246	1,690,000	(684,450)	+
Georgia	1977	427	167,000	(67,635)	+
Illinois	mid-1940s	2,130	8,500	(3,442)	+
Indiana	1980	116	3,485	(1,411)	+
Iowa	1980	239	2,600	(1,053)	+
Kansas	1973	1,527	173,399	(70,226)	+
Kentucky	1977	13	2,179	(882)	−
Louisiana	1978	575	420,000	(170,100)	+
Maryland	1977	369	61,500	(24,907)	+
Michigan	1977	757	184,322	(74,650)	+
Minnesota	1967	55,841	708,200	(286,821)	+
Mississippi	1977	241	724,980	(293,617)	+
Missouri	1955	13,758	207,777	(84,149)	+
Nebraska	1977	2,180	46,879	(18,986)	+
New York'		1,400	460,000	(186,300)	+
N. Carolina	1948	7,680	192,866	(78,110)	+
N. Dakota	1979	586	8,500	(3,442)	+
Ohio	1979	144	16,565	(6,709)	−
Oklahoma	1971	797	64,633	(26,176)	+
Oregon	1981	79	10,726	(4,344)	+
Pennsylvania	1936	28,000	3.9 mil.	(1.6 mil.)	+
Rhode Island	1948	50	75	(30)	−
S. Carolina	1978				−
S. Dakota	1977	1,025	28,000	(11,340)	+
Tennessee	1950s				−
Vermont	1980	212	30,086	(12,185)	+
Wisconsin	1975	100	7,876	(3,190)	−

[a]Does not include states reporting only technical assistance programs.

of private lands. Wetlands are critical habitats and the most threatened, and thus receive attention out of proportion to their relative occurrence. Intensively used farmlands have the greatest need for management if they are to produce wildlife, and most state programs are centered in the farm states.

Minnesota, North Dakota and South Dakota have the largest budgets for habitat purchases and management of all the states, primarily because of wetland habitats needed in waterfowl production. The Corn Belt states of Kansas, Illinois, Indiana, Iowa, Missouri, and Nebraska are leaders in habitat management for pheasants and other upland game birds. States in the southeast and northeast have programs directed at big game and small game species, and practically all states believed that what is being done for game species also favors non-game.

Table 3. State budgets, sources of funds, species featured, and name of programs for wildlife habitat management on private lands.[a]

State	Most recent amount budgeted (dollars)	Source of funds	Species emphasized	Name of program or activity
Arkansas	$ 78,000	Appropriated by legislature and game and fish funds	All species	Acres for Wildlife
Colorado	212,840	License fees	Pheasant	Pheasant Habitat Program Wildlife Habitat Improvement Program
Florida	40,000	Appropriated by legislature and license fees	Deer, waterfowl	
Georgia	3,960	Appropriated by legislature and license fees		Acres for Wildlife
Illinois	25,000	License fees	All species	Acres for Wildlife Private Lands Habitat Program
Indiana	37,000	License fees Habitat stamp	Pheasant, turkey, quail, nongame species	Game Bird Habitat Program Wildlife Habitat Cost-Share Project Wildlife Habitat Trust Areas
Iowa	182,000	License fees	All species	Switchgrass Program Farm Game Habitat Program
Kansas	59,176	License fees	All species	Wildlife Habitat Improvement Program
Kentucky	8,420	License fees	All species	Technical Guidance Program
Louisiana	114,000	Appropriated by legislature	All species	Acres for Wildlife
Maryland	7,444	License fees	Waterfowl and upland game species	Waterfowl Restoration Program Acres for Wildlife Cooperative Managed Hunting Areas

Table 3. Continued.

State	Most recent amount budgeted (dollars)	Source of funds	Species emphasized	Name of program or activity
Michigan	466,623			Land Lease Program for Public Hunting
Minnesota	4,570,000	General funds appropriated by legislature Game and fish funds	Waterfowl, deer, pheasant, nongame	State Water Bank Wildlife Habitat Improvement Program Wetland Tax Exemption and Credit Program
Missouri	1,050,921	License fees and sales tax (⅛ of 1%)	Upland game and forest game	Planning Ahead for Wildlife Survival Program Field Services Program Expanded Private Land Habitat Program
Montana		Tax deduction	Big game	Conservation Easement Program
Nebraska	900,000	Habitat stamp	Pheasant	Wildlife Habitat Program
New Hampshire		Tax deduction	Forest wildlife	Current Use Assessment Law
New York	86,875		Upland game	Farm Cooperative Planning Program
North Carolina	79,700	License fees	Deer, dove, bobwhite, rabbit	Public Hunting Grounds (RENEW) Program Wildlife Habitat Improvement Planting Materials Program
North Dakota	555,000	Habitat stamp Interest money program	Upland birds	Wildlife Habitat Restoration Programs for Private Agricultural Lands
Ohio	79,000	License fees	Upland game	Wildlife Habitat Restoration Programs for Private Agricultural lands

Table 3. Continued.

State	Most recent amount budgeted (dollars)	Source of funds	Species emphasized	Name of program or activity
Oregon	400,000	License fees	Big game	Green Forage
Pennsylvania	1,039,069	License fees	Pheasant	Cooperative Farm Game Program Pheasant Recovery Program Safety Zone Program Cooperative Forest Game Program
Rhode Island	3,000	License fees	Forest game	
South Carolina	66,000	Appropriated by legislature State duck stamp	Quail, rabbits, dove, waterfowl	Small Game Program
South Dakota	610,000	License Fees Pheasant restoration habitat stamp	Pheasant	South Dakota Pheasant Program
Tennessee		License fees	All species	Farm Game Program
Vermont	65,475	Anterless deer hunting permits License fees	Forest wildlife	Wildlife Habitat Improvement Program
Wisconsin	121,000	License fees	Quail	Acres for Wildlife Experimental Quail Management Wisconsin Project Respect

[a]Only states that provided more than technical assistance in 1982 are included.

Considering the amount of land held in private hands and the increasing demand for hunting and other recreational pursuits involving wildlife and wild lands, state (and federal) programs are very small indeed. What is being done is valuable and needed; however, sufficient acreage is not being impacted to even keep pace with the loss of habitat each year. About 2,000,000 acres (810,000 ha) are lost every year through development projects and through schemes that intensify production systems at the expense of wildlife habitat (Horvath 1976).

Walton (1981) summarized the problem: "None of the array of programs now in action can effectively handle all developmental pressures." McConnell (1981), speaking at the same symposium, stated that "The problem is simply too massive for wildlife agencies to solve alone with their funds and personnel. We must continue to use all the tools available to us, including acquisition, easements, technical assistance, monetary incentives, education, regulation, and political action. All have merit, but they are only tools." Teer and Burger (1981) concluded, "In view of the factors discussed previously, including land and crop values and farmer attitudes, plus growing national and international pressures for more food from a shrinking acreage base, it seems unrealistic for agencies to continue to push for major habitat improvements on our prime farmlands."

What can be done to enlarge the effort on private lands?

Commercial Hunting as an Incentive to Practice Land Management

Commercial hunting is not a new idea; it has been practiced and recommended by many wildlife managers. Berryman (1957) proposed that some system of compensating the landowner for producing wildlife, especially waterfowl and upland game, be initiated. Burr (1930:28), writing in defense of fee hunting in Texas, said:

> Nobody any longer talks about free cattle range, or free cotton land, and we expect to pay for our beefsteaks and gasoline, but there lurks the feeling that we should have free shooting. It seems not to have occurred to us that game is also a product of the land which shares the grasses and foliage with other stock on which the landowner is depending for a living, and that if there is to be justice in this ideal republic of hunting, the landowner must have a share in the stake.

In the "Report of the Committee on American Wild Life Policy," Leopold (1929) stated the compelling incentive for game management:

> Fear of impending scarcity, coupled with a desire to study, admire, shoot, or eat game, are valuable incentives, but do not of themselves impel action over large enough areas. To induce wide-spread production of game on private lands there must also be the incentive of profit to the landowner.

In its final policy statement at the 17th American Game Conference in a paper widely known as "The American Game Policy" (Committee on Game Policy 1930), the Committee listed three ways to promote management of wildlife on private lands:

1. Buy him out, and become the landowner.
2. Compensate him directly or indirectly for producing a game crop and for the privilege of harvesting it.
3. Cede him the title to the game, so that he will own it and can buy and sell it just as he owns, buys, and sells his poultry.

The Committee endorsed the second incentive. It pointed out that the public trust could not afford to purchase as much land as needed, and to cede title to the landowner harkens to the English system which is "incompatible with American tradition and thought." We believe the judgment of the Committee was sound then, and is as imperative today as it was when the American Game Policy was written.

Marketing of wildlife through commercial hunting is a controversial issue and is certainly not championed by those states with large acreages of public land, or elsewhere where free hunting and open ranges are longstanding traditions. Most hunters do not wish to pay for something they consider a heritage or cultural right. The increasing costs of licenses to hunt are already considered excessive by many. Wildlife belongs to the people, and most persons consider entering another's land for the purpose of rendering game to possession is a justifiable and legal right. On the other hand, those who control the land through ownership or management rights are beginning to ask for returns for providing hunting and other recreational opportunities. Those who take the risks in managing for agricultural crops, including wildlife, expect to be rewarded for their management.

The increase in commercial hunting is occurring primarily in extensively managed, privately owned forest, range, and wetland habitats. If not increasing, its practice in the 17 western states is well established and is being maintained as a prominent system of harvesting wildlife. Commercial enterprise has been a common practice of those who own land adjacent to huge areas of public lands. Many clubs and hunting groups have bought lands or access rights for the sole purpose of obtaining exclusive rights to hunting recreation in the mountain states of the West. Outfitting and the provision of accommodations often are parts of the hunting system.

By and large, the farming areas of the Midwest, Lake, Plains, and Eastern States have not practiced commercial hunting because management of wildlife in valuable cropland is costly to the farmer, the tradition of free hunting and trespass is generally accepted there, and upland game populations have been depleted in the past three decades by intensive farming practices. Commercial hunting also is not widely practiced on southern forest lands, primarily, it seems, because of social and cultural mores held by the people of the region. Some large industrial forests are being leased, and many companies are beginning to look at commercial hunting as a form of economic diversification. However, the negative values of restricting access have caused many companies to hold back. They fear reprisals—arson, tax increases, vandalism, liability, and other injuries. To avoid these reprisals, many companies are using their wildlife resources in public relations programs.

Wetlands of all regions have traditionally been objects of commercial hunting because they are limited in amount. The big game ranges of Texas and some other states have very highly developed and structured leasing systems. Landowners in these areas are conditioned to consider wildlife as a land value in market systems as well as sources of income from year to year. Unfortunately, there are no national or even regional studies of the dimensions of commercial hunting in the United States. The best that can be done is to give examples of the kinds and costs of leasing systems in several regions.

The best case study is that of Texas. Briefly stated, the roots of commercialization of hunting in Texas are in (1) the lack of public lands to which the public has free access, (2) the trespass laws which are vigorously enforced, and (3) the large amount of game on extensive range and forest lands of the state. Teer and Forest (1968) documented the trends in leasing arrangements in Texas from the 1920s through the late 1960s. They reported practically every one of the 254 counties in Texas had commercial hunting arrangements on private lands, and that a ten-fold increase in the amount of land leased had occurred between 1929 and 1963. Prices at the time were about $1.27 per acre. Leases are now bringing upwards of $10 per acre (Henson et al. 1977) for the better wildlife ranges. Quail hunting is becoming a major item in leasing arrangements, and many leases are being made for up to $6 per acre (average $2 to $3 per acre) in South Texas where unmanaged quail populations often exceed those of the managed ranges in the Georgia and Florida plantation country. Berger (1974) reported that hunters paid landowners in Texas $108,000,000 for leases in 1971. This is probably a minimal estimate for the time, and certainly has increased since 1971.

Hunting of exotic animals is an expanding dimension of commercial hunting in Texas. Introductions of exotics began in the early 1900s and several species are now widespread on ranches throughout the state (Teer 1975). These species are largely from the Orient and Indian sub-continent and include the black-buck antelope, axis deer, fallow deer, and nilgai antelopes. Curiously, of the great many trials of African species, only the Aoudad or Barbary sheep has become established in wild, unhusbanded populations. Many other African species are kept on ranches where they are fed and housed and in other ways managed, but none figure prominently in sport hunting. Prices for these animals are very high. A trophy black-buck antelope will bring upwards of $2,000; an axis deer, $1,500. Many ranches with exotic animals provide accommodations and food, and the hunt will be packaged with these and other amenities.

Leasing by large corporations, especially energy companies, for hunting all species of wildlife is increasing. Several counties in the Rio Grande Plains and Edwards Plateau regions of Texas have large numbers of such leases, and some of the best game ranges and hunting have been placed out of reach of the average hunter by the very high prices of these leases. It is not uncommon for an industry to provide first-class sport hunting of wild populations of game animals at an annual cost of a half to three-quarters of a million dollars. The companies use hunting as a form of entertainment for which they expect to promote sales of their products and services. On a scale such as this, returns from the sale of drilling rights, or pipe, or some service may recover the entire investment from a single customer.

Management for trophy deer in the Rio Grande Plains of Texas is becoming the major strategy in deer management in the region, as contrasted to the heavily hunted, dense populations of deer in the Edwards Plateau and other well known deer ranges in the state. Trophy deer management is becoming a symbol of the times in wildlife management. Leases for taking a trophy buck may go as high as $3,000 per animal, and practically no season leases are available in the region for less than $5 per acre. Even with such prices, there is not sufficient acreage to meet the demand, and the market increases eacy year for quality deer and quail hunting. About 258,000 persons (46.7 percent of persons 16 years or older who hunted or fished in Texas in 1980) either leased land or owned land on which they hunted (U.S. Department of the Interior and U.S. Department of Commerce 1982). They fished or hunted on 259,385,400 acres (105,051,087 ha) of land, and it may be surmised that most of the activity was done by hunters who paid a fee for hunting privileges.

Commercial hunting clubs such as the American Sportsmans Club and hunting "brokers" are numerous and active in wildlife harvest programs throughout the western United States. One has only to look in the national hunting magazines and classified sections of newspapers to get an idea of the size of this emerging business.

Many of the most productive wetlands in the nation are hinged in the marketplace. The Illinois River Valley and Chesapeake Bay duck clubs, the commercial goose hunting systems of the ricelands of Texas and the cornlands of Missouri, Wisconsin, and Illinois, duck hunting clubs of the Central Valley of California, the green tree reservoirs of Arkansas, and the leasing systems of the great coastal marshes of Louisiana are cases in point. There are no hard data on the values of these hunting systems to those who control the land. We only know it is a substantial amount. The October 14, 1982 issue of *The Cameron, Louisiana Pilot* newspaper carried a story concerning Cameron Parish leasing seven sections of its land for a total of $64,570 for three years for duck and goose hunting. Leases ranged from a low of $1,664 to a high of $15,000, and more than 40 persons bid on the seven sections.

The Future

In many central and eastern European countries, hunters are themselves responsible, within the context of national rules, for both harvest and management of game species. Hunters are grouped into associations (each with a game manager—an association member-hunter with additional training), responsible for habitat management and stocking, as well as for liability insurance for hunter-caused damage and compensation for any damage by game to crops (Burger and Teer 1981). In western European countries, game belongs to the landowner, rather than to the state, and the landowner sells hunting rights and the animals themselves after they have been brought to bag.

Harvesting and producing wildlife on private lands in North America is trending toward the western European system, largely due to the need for those who manage the habitat and produce wildlife to receive a reasonable reward for their efforts. At the moment, the users pay system is most highly developed in Texas, where exotic animals are owned and sold just as is native game in Europe and where hunting leases account for the bulk of the harvest of more that 300,000 white-tailed deer each year. This system is spreading to other species in Texas and elsewhere. Much of the better game range (terrestrial and wetland habitats) is being taken up by leasing arrangements of hunting clubs and industrial-business organizations. Commercial hunting has been a form of harvest in many of the great marsh and estuarine habitats throughout North America for many years. The commercial hunting systems attendant to the public lands of the West are also well established. We believe the system is needed and effective in protecting wildlife resources. It is, in our view, the strongest incentive for landowners to produce wildlife.

It need not be the only system or incentive to produce wildlife, however. The state and federal programs for protecting critical habitat and providing access to hunters for entering private lands are needed and valuable. In the long term, as expressed by Harmon (1975), "the final decision of how much wildlife is produced on private land rests squarely on the shoulder of the consumer."

What can we predict for the future?

Some rather pervasive changes in the collective philosophy and attitudes of governmental agencies and by those who own and manage the land will be effected by the users pay system. Among the most important changes to be expected are (1) in the long term, the number of hunters and fishermen will decrease, but the quality of their outdoor experiences will be enhanced by control of their numbers; (2) more of the nation's citizenry will become involved in dispersed, non-consumptive uses of wildlife resources; (3) state game and fish departments and other conservation agencies, public and private, will increase their emphasis on assisting the producer of wildlife as much as they presently assist the user or harvester; and (4) the users pay system will likely be adopted by governmental agencies controlling the huge acreages in the nation's public lands to generate funds for management. In our view, these are desirable outcomes which will insure wildlife resources for the future.

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Economic Incentives as a Conservation Strategy for Nongame and Endangered Species of Wildlife

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During man's relatively brief existence on this planet, he has relied on the bounty of its flora and fauna for his existence. He has used wildlife for food, clothing, shelter, medicines, beasts of burden, pets, and companionship. Over most of this period, this harvesting and exploitation had a modest impact on those resources. Only in recent centuries has man's exploitation begun to seriously harm wildlife resources. Western exploration and colonization quickly created serious problems for wildlife and led to a rise in human-caused extinctions.

The problem of maintaining genetic diversity, preserving endangered plants and animals, and preserving sufficient habitat is both critical and growing. The rapid loss of wildlife and especially of habitat is reported in *The Global 2000 Report* (Council on Environmental Quality 1980), Norman Myers' *The Sinking Ark* (1979) and the Ehrlichs' *Extinction* (1980). For example, *The Global 2000 Report* (pp. iii, 3, 37) warned of:

> the potential for global problems of alarming proportions by the year 2000. . . . the earth's carrying capacity . . . is eroding. . . .
>
> Extinctions of plant and animal species will increase dramatically. Hundreds of thousands of species—perhaps as many as 20 percent of all species on earth—will be irretrievably lost as their habitats vanish, especially in tropical forests. . . .
>
> Finally, the world faces an urgent problem of loss of plant and animal genetic resources. . . . between half a million and 2 million species . . . could be extinguished by 2000, mainly because of loss of wild habitat. . . . Extinction of species on this scale is without precedent in human history. . . .

Arguably, many of the large, aesthetically attractive species may be saved in zoos, preserves, and safari parks. But to preserve these species in the wild, and to save the untold numbers of plants, invertebrates and the smaller fish, amphibians, reptiles, birds, etc., we will need to preserve their habitats. There are two important aspects to the problem. First, the burgeoning illicit trade in wildlife products (which has encouraged overharvesting of the more valuable species) together with the poaching of endangered species even in the most protected parks and preserves is rapidly outstripping the financial resources of most Third World

[1] The views expressed by the authors do not necessarily reflect the official policy of the Department of the Interior.

(and many developed) countries to cope with the problem. The sole reliance on legal protection as a wildlife preservation tool may have reached its limits.

But secondly, and more importantly, the vast majority of species losses are no longer due to man's taking in the wild. Instead, the rapid growth of human populations is eliminating many wild places altogether, because of demands for food, fiber, housing, and energy. For example, in southern Kenya adjacent to some of the largest and most important national parks, the human population is growing at 8–10 percent annually (Myers 1982). No amount of enforcement is going to keep the people from converting wildlife habitat to farm land and grazing land, nor prevent people from poaching elephants and rhinos, slaughtering wildlife which compete with cattle for grass and water, and killing off predators. In spite of Kenya's well-publicized, able and well-financed efforts at protectionism, over the past decade its elephant population dropped from 165,000 to 50,000 and the rhino population from 15,000 to less than 1,000 (Myers 1981).

Out of this dismal picture has come an awareness on the part of a small, but increasingly influential group of conservationists, scientists, and economists that unless the living resources and habitat can generate some benefits, in the long run protectionism is pointless. The alternative pressures for development will cause the wildlife to be eliminated and much of the habitat to be converted to farm land, grazing pastures, or simply cut down for fuel and housing materials—and at best only converted to monoculture woodlots or plantations. Motivated less by philosophical concerns than by the practical urgency of the current crises, this group has called for greater reliance on economic incentives and private property rights to encourage people to harvest wildlife on a sustained-yield basis and to preserve the habitat. The noted conservationist Norman Myers (1981:36) recently wrote: "If it [Africa's wildlife] is not economically self-sufficient, there is little point in saving its living space. If it pays its own way, some of it will survive. If it can't, it won't."

In their efforts to stem the loss of wildlife, the nations of the world have relied primarily on trade restrictions, publicly maintained habitat, and governmental control of the rate of exploitation. The results have been mixed at best. Illegal taking and trade have severely taxed enforcement resources, and public budgets for habitat protection have been inadequate to withstand the press of development. Many observers are resigned to the belief that the best that can be expected from the current preservationist strategy is a postponement of the inevitable depletion of species, habitat, and ecosystems.

One of the principal reasons for the discouraging results of the preservationist efforts emanates from the status of wildlife as a common property resource. Wildlife are considered to be in the public domain, to be owned by all and hence by none, to be common property. The property rights theory is to a large degree based on the work of such economists as H. Demsetz (1967), H. S. Gordon (1954), and A. D. Scott (1955) and ecologist-biologist G. Hardin (1968)[2].

Demsetz (1967:354–356) defines communal (common property) ownership as:

[2]For other applications of the property rights theory to wildlife, see Davis et al. 1973, Myers 1981, Smith 1981, 1982, and Stroup and Baden 1979.

a right which can be exercised by all members of the community. . . . The community denies . . . to individual citizens the right to interfere with any person's exercise of communally-owned rights. Private ownership implies that the community recognizes the right of the owner to exclude others from exercising the owner's private rights. . . .

Suppose the land is communally owned. . . . If a person seeks to maximize the value of his communal rights, he will tend to overhunt and overwork the land because some of the costs of his doing so are borne by others. The stock of game and the richness of the soil will be diminished too quickly. . . .

If a single person owns the land, he will attempt to maximize its present value by taking into account alternative future time streams of benefits and costs and selecting that one which he believes will maximize the present value of his privately-owned land rights. . . . It is very difficult to see how the existing communal owners can reach an agreement that takes account of these costs. . . .

[P]rivate ownership of land will internalize many of the external costs associated with communal ownership, for now an owner, by virtue of his power to exclude others, can generally count on realizing the rewards associated with husbanding the game and increasing the fertility of his land. This concentration of benefits and costs on owners creates incentives to utilize resources more efficiently.

Common property status for wildlife puts almost the entire burden for preserving wildlife on the public sector. It does nothing to motivate the self-interest of individuals and create private incentives to husband wildlife or preserve habitat. Protectionism has failed to halt the precipitous decline in wildlife populations and habitat. If the decline is to be stemmed, the current strategy will have to be augmented, and a likely candidate for that augmentation is to permit the self-interest of private property and the market to help maintain wildlife and habitat.

Clearly, commercialization and private property rights cannot be readily applied to all wildlife. Our interest is in identifying those situations in which commercialization is consistent with conservation of the species and improves upon a pure preservationist strategy. Our approach has been to examine trade in a number of species to attempt to determine whether pressure on wild populations was relieved.

The work presented here is illustrative; we have chosen three examples of private property systems that demonstrate that wild animals can be commercially exploited under a system of private property incentives without the excesses that are commonly associated with trade in wildlife under a common property structure. The examples are eiderdown production in Iceland and crocodile and butterfly production in Papua New Guinea (PNG).[3]

Seabirds

In Iceland, private property rights have been extended to the common eider *(Somateria mollissima.)* The eider supplies meat, eggs, and especially eiderdown for the farmers and local populations. As early as 1281, the civil and ecclesiastical codes stated that the eiders "belong to the occupiers of the lands where they

[3]In the official terminology of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, "farming" involves closed-cycle, captive-breeding of wildlife, while "ranching" involves taking eggs or young from the wild and rearing them in captivity. For the purposes of this paper farming will be used for all controlled-rearing activities.

occurred." The farmers have protected the eider nesting colonies for centuries and actually farm them. Robin W. Doughty (1979:346) writes:

> Skuli Magnusson, pioneer agriculturalist and industrialist, and others, who protected and farmed the nesting places of wild eiders for down and eggs, promoted the concept of farming. In the 1770s, Magnusson protected a very large colony on the island of Videy, where reportedly he gathered and cleaned about 90 pounds of down from his "favorite" birds. On a visit to the same place in 1810, Sir George MacKenzie noted that eider ducks were "assembled in great numbers to nestle," and that severe penalties were imposed on persons killing them.

The number of such farming operations grew during the nineteenth century and peaked during the 1920s, when there were more than 250 farms. The movement of many farmers into towns, together with the development of synthetic substitutes, have reduced the number of farms to about 200, and eiderdown production is now about half of its peak figures. One result of this decline has been an increase in predation on the eiders by gulls, ravens, and feral mink and fox. Even though the number of wild predators has increased, the eiders are still carefully protected on the existing farms, where property owners shoot and poison predators.

The private eider farms have benefited both the property owners and the eider population. The farmers have protected the birds from overexploitation, from poachers, and from natural predators. They have also created artificial nesting sites in which the female will nest.

A small amount of down is carefully removed from each nest. Approximately 35 nests produce one pound (0.45 kg) of down worth $300. The island of Vigur is farmed by one family and the 4,000 pairs of eiders produce 60 percent of the family's income. The owner says, "It's like raising sheep for their wool" (Hyman 1982:6).

The farmers on other islands also reap a substantial harvest of seabird eggs (and young) from the steep sea cliff breeding colonies of common murres *(Uria aalge)*, razorbills *(Alca torda)*, and black-legged kittiwakes *(Rissa tridactyla)*. On Grimsey, the eight farms each harvest about 1,500 eggs a day, and the total take in the season is about 35,000 eggs. The eggs bring $10 a dozen in the mainland towns.

Under this arrangement the seabird populations have thrived. It has been found that if fresh eggs are taken early in the nesting season, most birds will lay new eggs to replace those which are harvested. By utilizing the management technique of "double-clutching," as well as a limited take of nestlings, which have a high natural mortality rate, this harvesting does not reduce the annual crop of young. Hence the eggs are a valuable renewable natural resource.

On the Westmann Islands, local residents harvest some 100,000 sub-adult, non-breeding common puffins *(Fratercula arctica)* annually. The feathers and down are used in bedding and the meat is sent to the mainland towns. By restricting their take to non-breeders, they preserve the biologically important breeding population.

In contrast, in the old days Iceland's nesting cliffs were called the "country's breadbasket," and over the centuries as many seabirds as possible were slaughtered. They were hunted at sea and on land with nets, hooks, snares, and guns. Many species had severe population declines and the great auk *(Pinguinus impennis)* became extinct. Today, with a private property structure replacing the birds' common property status, the populations have recovered and are thriving (Hyman 1982:8–10).

Crocodilians[4]

The crocodilians (crocodiles, caimans, alligators, and gavials) have been on earth for up to 200-million years. But the remaining 26 or so species have all undergone such rapid depletion during the past 30 years that most of them are now listed as either threatened or endangered, and the prospects for their survival in the wild is tenuous at best.

In the face of a continuing world-wide demand for crocodilian leather products, including shoes, boots, purses and handbags, wallets and billfolds, belts, watch-bands, briefcases and suitcases, there is little future for crocodilians if they remain only a common property resource.

Papua New Guinea has seen its wild crocodile populations crash in a short period of time following the wide-scale development of commercial shooting beginning in the mid-1950s. PNG has two species of crocodiles: the saltwater *(Crocodylus porosus)* and the freshwater *(C. novaeguineae novaeguineae.)* The trade in both species peaked in 1965–66 when $1-million in skins were exported. After 1966, exports plummeted as both species disappeared from accessible areas. By 1967 both species were threatened with extinction, and in 1968, even with increased hunting effort, the yield dropped by half. By 1969 the saltwater crocodile had disappeared from most of its range throughout the country. In 1970 the PNG government estimated that all breeding age crocodiles would be gone within five years. In 1971–1972 the total value of exports of both species had been reduced to $198,000.

In the late 1960s the government began to develop a radical national plan to incorporate all of the nation's wildlife as part of a constitutionally protected, sustainable national resource. In 1968 the government formulated its first crocodile regulations, including licensing at all stages of the trade, data collection, and most importantly a ban on the sale and export of all skins exceeding 20 inches (51 cm) in belly width (about 8 feet [2.4 m] long) which represented the most critical portion of the population, the mature breeding adults. (There was no attempt to institute a ban on the killing of crocodiles for domestic consumption—which the government believed the people would not support. Traditionally, the natives had harvested only young crocodiles and eggs for food. Adults were not harvested until the international skin trade developed.)

The national plan culminated with the enactment of the 1969 Crocodile Trade Protection Act which aimed at controlling the export trade, eliminating pressure on breeding adults, and developing a nationwide program of involving local peoples in farm-rearing young crocodiles to a marketable size.

The government set up a three-tiered system of farms with loans, training, and informational booklets and guides. In addition, the government began establishing training centers and research farms in 1969. By 1975 there were eight such operations. These have since been consolidated into four demonstration farms and one large research farm.

The program went into operation in 1972 with the creation of a first tier of 300

[4]Information in this section is based on research being conducted by the National Academy of Sciences. Publication of the Academy's report is scheduled for mid-1983. Other references include Ashley, no date, and Papua New Guinea Wildlife Branch 1975.

small village farms, essentially holding pens for the young crocodiles captured by the natives. These are pole and rattan enclosures capable of holding a total of 300–500 animals in each village. A 70-page Crocodile Industry Training Manual is distributed throughout the country to instruct villagers in pen construction, force-feeding of young, general care and husbandry techniques, etc.

The second level of small business farms holds up to 3,000 animals, is located near bush airstrips, has some ready source of animal protein for feed—generally trash fish or offal—and supplies the third level of larger company farms, which have a holding capacity of up to 20,000 animals. These farms are substantial operations requiring about $250,000 to establish, are located adjacent to major population centers, and have a reliable supply of food and fresh water.

Each tier sells stock to the higher level as they grow to market size and move towards the export facilities. Each higher level is better financed and better equipped, and is required to absorb the stock of the lower levels in case of food shortages, droughts, or periods of depressed market prices.

Currently the largest farm holds 8,000 crocodiles and is associated with a poultry farm which supplies offal for feed. In 1981 the nationwide farming system held a total of about 30,000 crocodiles, producing a sustained production of 10,000 skins annually worth $1–2-million dollars at the export price of $100–200 per skin. The ultimate goal is to maintain a population of 100,000 crocodiles producing about 30,000 skins per year for export. At full operation the government expects to be able to provide all its exports from captive-reared stock. At present, wild hunting of crocodiles (between 10 and 20 inches [25 and 51 cm] in belly width) and farming still coexist. It will take a while to shift from wild hunting to total pen rearing. (In 1975, the wild harvest was still about 25–50,000 skins.)

This system of controlled taking from the wild and farming has produced a ten-fold increase in the value of crocodilian exports since 1971–72, the result of replacing overexploitation of a common property resource with a property rights incentive system augmented by governmental management measures. In 10 years the industry has become the main source of income for the people of many lowland swamp and river areas, and in some areas it is proving more profitable than coffee and rice production.

The entire incentive and marketing system is aimed at seeing that no skins under three years old are exported. There is a considerable wastage of potential value in the export of small skins—those less than 10 inches (25 cm) in belly width—because the most valuable skins in international trade are 10–20 inches (25–51 cm) wide. In 1975, the government instituted an export tariff of 50¢ per belly inch to discourage the export of small skins. Education had not eliminated the continued export of small skins. The 50¢ per belly inch tariff seems to have worked. In January–February, 1975 a 6–7 inch (15–18 cm) saltwater crocodile skin brought $2.00, but the export tariff was $3.00–3.50. If the same crocodile were kept for two years on a farm, it would reach a 12–14 inch (30–35 cm) belly width, which would bring a total of about $30.00, less about a $7.00 tariff or $23 to the farming system. Total export value soon began to climb.

The PNG program seems to be achieving both conservation goals and profitable, sustained-yield harvesting of its once nearly vanished crocodiles. The International Union for the Conservation of Nature and Natural Resources approves of the program and granted it special dispensations. The saltwater crocodile is listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora as Appendix I and as endangered on the U.S. Endangered Species List, but the PNG population is listed on CITES as Appendix II and not listed by the U.S., thus permitting trade. Although, it has not fully surmounted the problem of the commons, Papua New Guinea has created a system whereby everyone has a stake in keeping the wild adults breeding. Further, the young crocodiles are raised to an optimal size for marketing, and many of those reared in captivity would have been lost to natural mortality in the wild.

Butterfly Farming[5]

Although butterflies pollinate crops and flowers and serve an important role in the food chain, commercially they are valued only for their aesthetic qualities. Taiwan, Korea, and Malaysia maintain factory-like operations where specimens are mounted in plastic and glass. Similar but smaller enterprises flourish in Honduras, Hong Kong, and several African nations.

The trade is divided between collector-exotics and common ornamental varieties, and is extensive. Taiwan alone sells somewhere between 15- and 500-million specimens annually; the take of the blue Morphos from the South American tropics is roughly 50-million per year. Despite the magnitude of the harvest, wild population levels in Taiwan seem to have been unaffected, and biologists estimate that reproduction rates are such that the harvest from South America could be doubled without detriment.[6]

In Papua New Guinea, where butterfly collecting and commercial harvesting had been conducted since the turn of the century, the experience contrasts sharply with that in Taiwan and South America. Although PNG remains largely an undisturbed rain forest populated by forest farmers, butterfly collecting had reached such proportions by the mid-1960s that several of the most exotic species (the birdwings) were endangered. Between 1966 and the mid-1970s PNG moved to protect its unique butterfly resources from overharvesting and to reserve any economic returns for PNG natives. Trade in the endangered butterflies was prohibited and penalized severely; preserves were established and research undertaken to promote recovery of depleted species; foreigners were excluded from engaging in commercial trade in butterflies; exports of live specimens were prohibited; and a system of butterfly farms (enhanced habitat areas on the fringe of natural environments) was developed. Although butterfly farming is conducted on a limited scale elsewhere (Australia, Malaysia, and the American tropics), in Papua New Guinea it is extensive, with 500 farms operating.

Farming

The farms are operated by villagers who plant flowering hibiscus to attract adult butterflies and leafy plants *(Aristolochia tagala)* for caterpillars to feed on. After

[5]Information in this section is based on research being conducted by the National Academy of Sciences. Publication of the Academy's report is scheduled for mid-1983.

[6]Some experts argue that although population levels have been unaffected, harvesting from the wild has not been benign, that the preference for larger, more billiantly colored, perfectly formed specimens alters the genetic composition of the wild stocks.

mating, the females lay their eggs on plants which will support larvae. After five molts, a larvae pupates, attaching a chrysalis to the underside of a leaf. Some farmers leave pupae in the open; others pluck them and put them in cages to protect them against predators (ants and rats). During the 2–3 week pupa stage, the chrysalises are sprayed with water 2–3 times a week to prevent them from drying out and to accelerate hatching. Some skill is required, because overspraying promotes mold.

Harvesting is a delicate matter, and timing is critical. If a specimen is killed too soon after emerging from the chrysalis, its wings will be flabby, and it will not be marketable. Waiting too long to kill a specimen runs the risk that the caged butterfly will inflict damage on itself.

Harvested specimens are dried, placed in grease-proof envelopes, and shipped in air-tight, wooden boxes to the government marketing agency (Insect Farming and Trading Agency (IFTA)) in Bulolo. Throughout, the specimens must be kept dry (to avoid mold) and protected from other insects. That skill is required in all this is apparent from the fact that only 50 of PNG's 500 farmers are consistently able to supply marketable specimens.

Marketing

Although the farms are run independently, the government maintains control over all other aspects of butterfly conservation and trafficking. IFTA trains village farmers, does research designed to increase productivity, and operates a marketing co-op, taking and filling all orders and maintaining quality control. For all this, IFTA retains 25 percent of the profits. Despite the scale of the farming program, cultivated butterflies account for only 30 percent of the specimens marketed, the rest being field collected. Farmed specimens generate half of the revenue, however, probably reflecting management of the habitat for more valuable species.

As a revenue raiser the program is modest: $180,000 was distributed to the villages during the first three years. There is significant potential for growth, however, since IFTA was able to fill less than 10 percent of the orders it received. PNG's goal is to export 5,000–10,000 specimens a month and generate $120,000 income per year for the villagers.

Conclusions

The foregoing cases provide examples of commercial activities in wildlife that are not based on the exploitation of breeding populations in the wild but rather on the rearing activities of private farms and in some cases controlled taking of non-breeders from the wild. In all cases, a system based on private or quasi-private property rights has been developed in an effort to avoid the overharvesting frequently associated with exploitation of common property resources in the wild.

In the case of the Icelandic eiders, nesting birds are attracted to private farms where they are treated as private livestock for the duration of the nesting season and cultivated for their eiderdown. Instead of down collection interfering with nesting, the eider farmers have every incentive to see that nesting is successful to insure the return of future year's breeders.

The establishment of crocodile farms in PNG created an incentive where none existed before for the nurturing of hatchlings to adult size. The advantages of the rearing-station farms over a closed-cycle, captive breeding structure are twofold. First, the farmers are spared the expensive difficulties of maintaining breeding populations, while the rearing of crocodiles to a marketable size on the farms makes it unnecessary to rely upon natural survival and growth of the hatchlings in the wild to provide a supply of crocodiles to the market. Nature excels at breeding a copious supply of young crocodiles, while man excels at rearing a high proportion of the young. Secondly, continued collection and rearing of wild hatchlings by the natives assures their incorporation in the overall program, and strongly encourages their cooperation. They contribute to it and reap the profits. They see that they benefit from maintaining wild populations. A closed-cycle farm, not dependent on a thriving wild population, would result in no one having a vested interest in maintaining the wild populations. Revenues would accrue only to the businessmen-farmers, inviting poaching in the wild by the natives.

Taken together, the program seems to have stopped the overharvesting of breeding adults, providing an opportunity for the species to recover. It will take a few years to assess the success of the recovery efforts, but it is clear that in the absence of the government's initiatives and the farming program, the crocodiles were doomed.

The Papua New Guinea experience with butterfly farming is comparable. By attracting breeding butterflies to their private plots, the farmers are able to capture a supply of larvae and pupae. At the same time, butterfly farming complements the hunting and gathering mode of life that characterizes New Guinean culture. This is an appropriate agricultural technique for an undeveloped country. Although the revenues are modest, if it can be combined with farming of other indigenous species, it may provide sufficient incentive to prevent deforestation and the conversion of habitat. Indeed, the PNG government has already begun to experiment with controlled harvesting and prototype farming of other tropical forest species, including the very valuable cassowaries (large, ostrich-like birds), megapodes (large, turkey-like birds which lay eggs in hot volcanic sands), wallabies (which are second only to fish as a source of protein for Papuans), and the elk-sized sambar deer.

Two major conservation questions are raised in conjunction with commercial exploitation of wildlife: are incentives to protect habitat affected, and does commercialization lead to mushrooming exploitation of wildlife (the market stimulation question)? The incentives for eider and butterfly farmers vis-a-vis habitat are obvious: the farmers own the property and protect it. But the best that can be claimed for the crocodile farms in PNG is that they have quasi-property rights in the wild. Although the crocodile farmers have a collective interest in preservation of the wild populations and their supporting habitat, the wild habitats do not now have the direct protection of a private property system, nor are they likely to have unless each crocodile farm acquires a private territory of breeding habitat sufficient to keep it stocked with progeny. A similar interest in the preservation of the wild exists for the butterfly farmers, because their breeding stock is non-captive and must be continually reattracted from the rain forest habitat. If development should threaten, the rain forest and marsh habitats might be vulnerable. If the necessary infrastructure were installed to make timbering feasible, PNG's wildlife industries would have to become more lucrative to stave off pressures to develop the habitat for alternative uses.

The essence of the market stimulation argument is that commercial trade in a species will stimulate demand and will result in overexploitation of wild populations. The argument has merit under two conditions: (1) a product is introduced, the market expands with awareness of its availability, legal sources are inadequate to exhaust the demand, and law enforcement efforts to suppress illicit trade are ineffective; or (2) demand for a product already exists, sanctions against commercial trade are relaxed, legal sources are inadequate to exhaust demand, and law enforcement is ineffective.[7] Neither of these conditions hold for the three species which we have examined. The products are all well-known and available, and markets in them have functioned for some time. The farming operations that we have examined constitute a minuscule percentage of the markets in their respective species, and it stretches the bounds of logic to contend that they could stimulate additional exploitation of the wild. It is much more likely that the output from these farms substitutes for taking from the wild.

We hold no brief that we have found a panacea for the world's wildlife problems. Clearly many, if not most, species will benefit only indirectly from commercialization. But because the outlook in those regions with the greatest natural abundance is so serious, the strategy of instituting property rights where there are commercial demands for wildlife products bears looking into. Further, the indirect or "umbrella effect" of protection for nonmarketable species through commercialization of neighboring species should not be dismissed. By preserving habitat for economically valuable species such as crocodiles or game animals, the ecosystem is maintained, and so too are myriads of commercially insignificant species which would otherwise be lost if those habitats were converted to monoculture forests, coffee plantations, rice fields, etc. While this may be an unintended result of the property rights approach, it is nonetheless a vitally important consequence of the use of economic incentives.

Based on what we have seen in the cases addressed in this paper, a single species or a group of species to be protected in a particular habitat would need to meet at least one of several criteria in order to be candidates for the use of commercial incentives.

1. The breeding adults must be amenable to at least semi-domestication or, failing that, they must predictably come to breed or hatch on privately controlled property as in the case of the eiders and butterflies.
2. If breeding populations must be maintained in common property status in the wild, then the farming activities which supply the markets with adults must be so successful at producing as to be able to essentially dominate the supply and curtail the illegal market for cropping from the wild. It helps also to have social and cultural sanctions which ostracize those who poach on the community supply. These conditions may, in part, fit the Papua New Guinea crocodile case.
3. The market demands for the wildlife products must be reasonably stable in

[7]One qualification deserves to be made to these two conditions. It is entirely possible that in the early stages after commerce is initiated, legal sources may have insufficient productive capacity to exhaust the market, but if given enough time to develop, these sources could replace taking from the wild. Under such circumstances the question to be addressed is whether the short-run costs (in terms of overharvesting of the wild) are worth the long-run benefits (in terms of relieving pressure on the wild).

order to sustain commercial farming for fairly long periods of time. Markets for Icelandic eiderdown and seabird eggs seem to meet this test. One hopes that world markets for butterflies and crocodiles will be equally long lived.

4. The government authorities or the private entrepreneurs must be willing to invest in research and demonstration activities that will improve and sustain the economic profitability of the farming and marketing activities.

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Toward the Progress of Wildlife Conservation in North America

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The theme of this conference is *Many People, Many Demands, One Land,* and the keynote session is entitled *Improving Resource Management*. The implication is clearly that there are conflicting demands and pressures on renewable natural resources, and that resolution of avoidable conflict can be sought through improved management.

At the same time, our session title, *Emerging Nonfederal Initiatives in Resource Management,* implies that improvements in management will include a broadened base of political involvement. Managerial objectives, for wildlife, are principally to maintain genetic diversity in the form of locally adapted races of wildlife, to optimize production and use of game species, and to alleviate damage-situations involving wildlife populations.

Broadly considering the state of wildlife management in North America, we should first take stock of where we are, and then attempt to sharpen our perceptions of where we should be going. The various perspectives brought to this task by the eminent contributors to this panel, taken together, help us develop a multi-dimensional view.

A century ago, in North America, unrestrained heavy hunting pressure had reduced big game populations to tiny remnants. Gradually this hunting pressure was brought under control by state licensing systems promoted by far-sighted sportsmen, the sporting arms and ammunition industry, and conservation groups. Federal involvement grew in areas beyond state interest or capability. International treaties helped the regulation of migratory bird populations. Funds were found for a refuge system, and for wildlife investigation.

One great result of these developments has been the general increase of all wildlife species, game and nongame alike, to the carrying-capacity of available habitat, through effective control of human predation. The species that have ample habitat are abundant; the scarcity of other species is a consequence of habitat poverty.

Habitats vary as the landscape changes, and landscapes change in response to managerial control. Managerial programs, in turn, are responsive to the objectives of the land's owners. Between public and private ownership, then, we would expect different managerial patterns and habitat outcomes. With wildlife in public ownership, as it is in Canada and the United States, it is logical that wildlife habitat quality should be considered positively in managerial planning. Despite conflicting objectives in public land management, there has been a recent trend toward more actual planning for wildlife in the management of public lands, particularly those under the administration of the U.S. Forest Service. Such developments are most likely to occur on the nationally-administered public lands, which are centrally administered and responsive to public opinions as mediated by Congress. On other public lands, state, local, or federal lands under diverse administrations, positive wildlife habitat management is seldom evident. Yet, as will be developed in a later section, such lands, as part of planned community wildlife enhancement districts, could make a major contribution to positive wildlife conservation in North America. One vehicle for this is the involvement of nonprofit organizations in their management, as reported by Yaffee (this conference).

Private lands are another story. Wildlife habitats on the private lands—notably croplands—of North America, have long been declining in quality and diversity (Taber 1968). The roots of this problem lie in deep-seated cultural attitudes developed in Europe long before the European colonization of North America. In Europe, and particularly in England, the mother-country for well over a century of North American Colonization, the land was largely owned by the wealthy and privileged, and farmed by tenant renters. With immigration to the New World, and particularly with the independence of the United States, there developed the concepts that outright land-ownership should be accessible to virtually all, and that wealth, per se, should not be a guarantee of rights beyond the average.

The North American owner of cropland, whether arable, grassland, or production forest, assumed virtual freedom to manage it as he wished. As settlement progressed, the early subsistence homesteads were merged and transformed into economic units managed for the production of cash crops. The cropland owner-manager emerged as a businessman, measuring the success of his management in monetary profit.

At times, when it has been considered in the national interest to influence the management of private lands, the desired programs have been presented as money-makers, or made acceptable by financial incentives.

Meanwhile, on another track, the wildlife resources were considered common property by the European settlers, with equal opportunity to all in their pursuit. Game was important, in pioneer days, as food, and fur and skins as items of trade. While household use of wildlife, for hunting and fishing recreation and for family food, continued, commercial wildlife harvest grew. When states began to sell hunting licenses, the proponents of the household use of wildlife—the sportmen—soon obtained legislation to eliminate the much smaller group that they perceived as competitors, the commercial harvesters—the market hunters.

Ready availability of hunting and fishing licenses, and the popularity of hunting and fishing, insured that license-buying sportmen would be numerous and that their interests would be recognized in state legislation. One example of this, highly relevant to the problem of wildlife on private lands, has been the widespread tendency to legislate weak state trespass laws. Except for Texas, where the private landowner has effective protection against trespass, the entry of sportsmen onto private lands to pursue the common property of game and fish has been relatively unhindered. This has made it difficult for the landowner to charge for access and so obtain income from the production of wildlife on his land, except in Texas.

The Texas experience has led some to believe that private cropland owners in other states would plan positively for wildlife if they had strong trespass protection and so could receive cash income from hunting access fees (Bolle and Taber 1962). Applegate (1981), in contrast, observes that while cropland managers are willing to cash in on a marketable wildlife production that is an unplanned consequence of their pattern of agriculture, he has seen little evidence of deliberate management to enhance wildlife.

The possibility that the agricultural owner will modify his management practices will be affected by at least three considerations: his security against unauthorized hunting; the per-acre economic productivity of his land; and his managerial habits. In the Texas case, wildlife income is important, according to Teer et al. (this conference), on lands of low per-acre productivity, where intensive management practices, and hence massive landscape modification, are not in order. The landowners in question have strong trespass protection, and the practice of charging for hunting access has been widespread, in their cultural community, for at least one human generation.

The "Texas plan" is not unknown outside of Texas, since wetlands are commonly leased or sold to waterfowl hunters at high rates, and hunting clubs arrange for leases of private lands for deer and other game. But as Teer et al. report in this session, there is a lack of reliable information about this topic. It appears that "fee hunting" is not encouraged by most state wildlife agencies, presumably because it is viewed as reducing overall hunting opportunity, and thus license sales.

There is a basic difference between traditional funding sources for U.S. state wildlife agencies, on the one hand, and Canadian provincial wildlife agencies, on the other. In the U.S., license fees go directly to the support of the state agency. Supplemental funding from state tax revenues is rare. As license income has lagged, and wildlife responsibilities have broadened, the state agencies have sometimes been unable to obtain the needed additional revenue (Spencer et al., this conference). In Canada, license fees go into general revenue, and support for provincial wildlife agencies comes from general revenue. Earlier, income exceeded expenditure, but now the reverse is true (Neave and Goulden, this conference).

During the years in which U.S. state wildlife agencies were reasonably well funded through license sales, there were many programs aimed at the improvement of wildlife habitat on private lands. Teer et al. (this conference) have provided the most recent review. Their conclusion is that these programs, however well designed, are miniscule in overall effect because of the great extent of private lands in proportion to the always limited financial capabilities of the public wildlife agencies. It does not seem realistic to expect that public wildlife agencies will be able alone to reverse the continuing decline of wildlife habitat quality on private croplands.

If we are going to make progress toward the objective of rewarding the manager of commercial cropland financially for enhancing wildlife diversity and abundance, we must start with the realization that we are working against strong cultural blocks in our own heads. Plenty of land managers would be amenable. Plenty of hunters would be amenable. It appears to be the profession of American wildlife conservation that has failed to pursue the dictum enunciated in the first American Game Policy, in 1930, that the cropland manager should receive financial rewards commensurate with his positive contributions to wildlife habitat quality.

The question raised by Applegate (1981) of whether one can find many examples of positive wildlife habitat enhancement on private croplands, is best answered by reference to Texas, where some positive habitat management is developing, and to western Europe, where it is very well developed indeed. Where there is a demand, and an economic mechanism whereby this demand can be met, the manager will be receptive to advice on how to increase production; that is the rationale for the positive accomplishments of agricultural extension.

Smith, et al. (in this conference) call attention to the fact that in North America wildlife is owned by the public, which ". . . puts the entire burden for preserving wildlife in the public sector." They present several examples in which control of wildlife populations, and freedom to benefit from commercial use, has led to successful wildlife management by private individuals. Significantly none of these examples is from North America, where the fact that wildlife is public property is the very reason that American wild game cannot be sold, and access to it, wherever it may be, is so persistently promoted by agencies serving the hunting public. Public ownership of wildlife has been at the root of the problem of wildlife habitat deterioration on private croplands over the last half century.

Now, private croplands are becoming private residential lands, and a major new potential for positive wildlife management is emerging. The United States is in the midst of a large-scale movement of well-educated, affluent citizens from cities to the country and small towns (Long and DeArc 1982, Blakely 1983). These people are moving to what they perceive as a residential environment of higher quality (Lee 1983). Their attitude toward rural land is in strong contrast to that of the traditional private cropland manager. For the cropland manager, his land is a business unit. He makes financial investments in the expectation of corresponding financial rewards. By the new rural resident, on the other hand, the land is viewed in a household sense (Bolle and Taber 1962). He freely makes financial decisions concerning it in the hope of rewards that are not economic in nature, rewards in the quality of life. Nielson et al. (1977) observe a characteristic tendency of newly rural exurbanities to guard the values of their new environment against deterioration, a tendency they term the *"last settler syndrome."*

Here is a huge number of potential cooperators in wildlife habitat improvement, both on their own lands and on public lands in their communities. They may or may not buy hunting or fishing licenses, but they can be guaranteed to be receptive to the message that their environment and that of their children and grandchildren can be enhanced through an active program of wildlife conservation. The represent a tremendous potential in energy, talent, and money.

How can this potential be made to produce positive improvements in wildlife habitat in rural regions where most of the land is privately owned? One can visualize most readily a development that is already under way, the response of exurban rural landowners to the guidelines for enhancing wildlife on residential grounds, as described in Thomas et al. (1973) in *"Invite Wildlife to Your Backyard."* Applegate (1981) noted that the National Wildlife Federation had distributed over one million copies of that article and ". . . certified over 2,000 backyards as "National Backyard Habitats," and no doubt this interest and response continues. At the same time, one can readily see that a scattering of wildlife supporters in a rural community could well provide the impetus for wildlife habitat improvement on a district scale, involving both private and public lands. There are many sorts of district organizations in rural areas, so the concept of a *Wildlife Conservation District* might be culturally acceptable. Progress toward the goals of wildlife conservation would depend upon the development and implementation of a district plan in which both private landowners and public land managers would play a part. Leadership and drive could well be provided by the public-private partnerships in conservation described by Metzger (this conference), the involvement of non-profit organizations in wildlife habitat management (Yaffee, this conference) and wildlife research by private conservation organizations (Miller et al., this conference).

These emerging nonfederal initiatives in wildlife resource management, the theme of our special session today, seem tailor-made for the task of working with the millions and millions of affluent, well-educated Americans who are flooding out of the cities in search of a better life. Here, for the first time in history, is an American landowning constituency that manages land for rewards beyond the dollar. Here is the opportunity to restore, in some measure, the wildlife populations on some of the most productive acres in North America.

Is the American wildlife profession capable of responding to the need?

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Comments on Emerging Nonfederal Initiatives in Resource Management

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I would like to suggest some implications and inferences that I believe develop from the papers we have heard—tempered, of course, by my own opinions. Let me begin with two quotes, the first from Metzger's paper:

> Massachusetts' dependence on outside agricultural production was perceived at a time when the decline in Commonwealth farming had reached truly alarming proportions: from 35,000 farms covering two million acres in 1940 to only 5,900 farms on 679,000 acres in 1978, with only 311,000 acres of actual cropland in production on the latter date.

and, secondly from Miller, Franklin, and Leedy's paper: "Approximately 1 million acres of agricultural land are converted to urban uses each year in the United States."

These quotes illustrate our most crucial, in fact survival issue: habitat loss, change, or degredation. Habitat—whether estuarine, forest, or upland—*suitable habitat is the issue.*

We have heard from state, provincial and federal agencies, from universities and private organizations—all talking to the point of emerging initiatives in resource management. And through all there has been a common thread: *how do we finance resource research, management, and habitat maintenance?*

We have heard of new and useful state and provincial initiatives; of the role of the nonprofit groups; and of the potential of some economic incentives. We have learned of some worthwhile and tested tools. And, that there are some real pitfalls. Obviously there are useful and needed approaches for specific species or situations; and all should be employed. But, we are talking about the resources of a continent, on all classes of land and water. We must ask ourselves: Do we want only to preserve islands of habitat, only remnants of fish and wildlife populations? Or do we want fish and wildlife resources to remain as a part of the fabric of our total landscape and environment?

If the latter is the case, and I believe it is—if this is really our "conservation ethic"—then we must undertake research and find ways to make the maintenance of habitat compatible and competitive with other land uses, because we can never generate enough revenue to acquire or control needed habitat.

This is the suggestion of the Canadian experience as reported by Goulden and Neave ". . . that the success of the manager will depend not so much on budget, but on his ability to influence major financial and land use institutions. . . ." And, on the U.S. side, by Metzger's observation that success depends as much on economic viability as on land use. Teer and Smith both made the same observation on the need for economic incentives.

We have never been faced with such competitive challenges to the multiple uses of a finite resource base—increasing world populations; the use of food and energy as diplomatic tools and trade offs; and domestic economic austerity that will not pass with this or succeeding Administrations.

Faced with these conditions we must learn to work with other resource users and to develop incentives so that habitat maintenance is attractive.

Why are we so slow? Why are we too often on the defensive? I think we, as professional fish and wildlifers have too long thought it repugnant to enter the marketplace. For too long we have viewed agriculture as the arch enemy, along with energy developers as the villains. We have too often approached our problems as adversaries and with a crusader's zeal. Obviously much of that was needed and helped turn the tide. But, success now depends upon our willingness to employ new approaches and every tool, including partnership and cooperation and especially upon our ability to influence political, financial, and land use institutions at the local, state, and federal levels, and to make wildlife economically viable. And, I want to stress: it is to our advantage to take the initiative—not to fight a rear guard action.

This is the message of the panel; this is the only way to assure that wildlife will always be a part of *all* of the North American scene.

Water and Wetlands: Policies, Planning, and Management

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Potential Developments in Fish and Wildlife Habitat Policies

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Before my discussion of policies specifically related to water and wetland resources, I would like to take this opportunity to announce a new Department of the Interior policy that has just been released. For the past two years, the Department of the Interior has been developing a Fish and Wildlife Policy to clarify the fish and wildlife responsibilities of the States and four Interior agencies—the Fish and Wildlife Service, National Park Service, Bureau of Land Management and Bureau of Reclamation. The policy also is intended to enhance State-Federal cooperative relationships and identify new areas for potential cooperative agreements.

In October 1982, we invited the public to comment on a draft of the policy and we were gratified by the positive response we received. We revised that draft, and the final Departmental Fish and Wildlife Policy: "State-Federal Relationships" was recently signed by the Secretary and published in the March 18, 1983, *Federal Register*.

The purpose of the policy is to foster improved fish and wildlife conservation by eliminating confusion regarding basic fish and wildlife authorities of the States and Federal Government. It further recognizes that effective stewardship of fish and wildlife requires the cooperation of the States and Federal Government. Copies of the final policy have been mailed to leaders of private conservation organizations and State and Federal wildlife-related agencies.

All of us in this room are concerned about the increased demands for allocations of water from our streams for urban and industrial water supply, irrigation, and energy development—i.e., hydropower production, slurry transport of coal, oil shale processing, etc.—particularly in the western states where water resources are limited. At the same time, we continue our efforts to maintain adequate flows and minimize stream habitat degradation and loss in order to support continued viable and productive commercial and sport fisheries. We are also concerned about the depletion of our wetlands that continues at an alarming rate and the associated losses of waterfowl breeding and wintering habitat and estuarine shellfish and finfish spawning and nursery areas.

It is estimated that more than 54 percent of all wetlands that existed at the founding of our Nation have been lost, and that losses are continuing at a rate of 458,000 acres per year. The aggregate trend is cause enough for concern, but the losses are all the more disturbing, concentrated as they are in areas where wetlands are most productive and their natural functions are most needed: the prairie pothole region of the upper Midwest, the coastal marshes along the eastern seaboard, the Gulf States, and California. The greatest percentage of loss of all wetlands and associated ecosystems has been caused directly or indirectly by agricultural activities (U.S. Fish and Wildlife Service 1982).

I believe it is likely that we will see an increased emphasis on these water and wetland issues in the implementation of existing policies and development of new ones. As I mentioned earlier, the Department's new policy on State-Federal relationships is intended to identify new areas for cooperative agreements. Those that could apply to activities related to instream flow and wetlands include protection, maintenance, and development of fish and wildlife habitat; fish and wildlife resource inventories and data collection; habitat preservation (e.g., joint processing of permits); and processing of State and Federal permit applications for activities involving fish, wildlife and plants.

In response to policies and objectives of the Department of the Interior, the Fish and Wildlife Service (Service) conducts research to improve fish and wildlife management information. The Service, in a Federal-State interagency cooperative effort, developed the Instream Flow Incremental Methodology that has a wide range of applications in addressing instream flow problems. This methodology has been used in over 500 locations in at least 34 states. In addition, the Service offers courses in the application of stream habitat analysis to water management, stream measurement, computer analysis, flow negotiation, and water law.

In 1974 the Service initiated an inventory of the Nation's wetlands. The mandate was to develop and disseminate a technically sound, comprehensive data base, concerning the characteristics and extent of the Nation's wetlands. The purpose of this data base was to foster wise use of wetlands, expedite decisions that may affect this important resource and monitor trends of wetland changes. To accomplish this, state-of-the-art principles and methodologies pertaining to all aspects of wetland inventory were assimilated. A series of detailed wetland maps were produced for geographic areas of critical resource concern to the Service. In addition, a statistical analysis of the wetland gains and losses between the mid-1950s and late 1970s in the conterminous United States was recently completed. The sample design and the computer programs for the analysis were developed also to generate flyway and State wetland estimates.

The Service also provides objective information and assistance regarding water use and development to construction agencies, primarily through its investigations of Federal water projects. The Fish and Wildlife Coordination Act, which mandates both Service and State fish and wildlife agency involvement in water resources development, is the most effective law regarding identification of project impacts on wildlife and development of alternatives to minimize or mitigate those impacts. The Service not only participates by investigating projects proposed by the Bureau of Reclamation, Soil Conservation Service, and Corps of Engineers, but also reviews and comments on Section 10/404 permits, hydropower exemptions and licenses, small navigation and flood control projects, etc. Representing the Departmental perspective, I have worked closely with the Service to insure that its review and comment on permits and projects is timely, effective, and "real world."

In the interest of serving the public, and consistent with the policies and objectives of the Department, the Service in 1981 developed a Mitigation Policy, which states that the Service will ". . . seek to mitigate losses of fish, wildlife, their habitats, and uses therof from land and water developments." In administering this policy, the Service strives to provide information and recommendations that fully support the Nation's need for fish and wildlife resource conservation as well as sound economic and social development through balanced multiple use of its natural resources.

The policy covers impacts to fish and wildlife populations, their habitat, and human uses thereof. However, the primary focus of mitigation recommendations is related to habitat value losses. Four Resource Categories are used to indicate that the level of mitigation recommended will be consistent with the fish and wildlife resource values involved. The policy also provides that the Service will fully coordinate with the State agencies responsible for fish and wildlife resources related to the investigation of project proposals and in the development of mitigation recommendations for resources of concern to the State.

A basic tool for evaluating project impacts that is used as the basis for formulating mitigation recommendations is the Habitat Evaluation Procedures. These procedures, referred to as HEP, were developed by the Service with the cooperation, manpower, and funding support of numerous State and Federal agencies. HEP is a habitat-based procedure to assess environmental impacts, provide a method of describing baseline conditions, and predict future habitat conditions in terms of fish and wildlife habitat quality and quantity. HEP is designed to be used in resource development planning and to overcome major problems associated with evaluations based on man-days of use and production of harvestable fish and wildlife populations. As habitat-based evaluation procedures, they can be used on various types of projects and in various stages of project planning. The procedures are flexible enough to meet the particular needs of the field level planner.

A HEP demonstration program was conducted from 1980 through 1982 to evaluate the institutional effectiveness and acceptability of HEP in water resource planning studies. Selected Corps of Engineers and Soil Conservation Service planning studies were involved in this joint effort with the Service. The results of the evaluation reconfirmed that HEP produces credible results in a scientific manner and is acceptable to the Corps, SCS, the Service, and State fish and wildlife agencies. They also reconfirmed the high level of acceptance HEP has already received from the educational and scientific community as an established habitat-based impact evaluation methodology.

HEP was used recently in a joint State-Federal effort to develop a mitigation and enhancement plan for Phase I of the Bureau of Reclamation's Garrison Diversion Project in North Dakota. The plan is founded on the concept of obtaining sufficient mitigation habitat credit units as measured by the HEP technique to overcome impacts on wildlife resulting from the construction of Phase I.

Although HEP was initially developed for intensive, site-specific applications, it is possible to adapt the procedures to other types of applications including:

1. Air photo interpretation studies;
2. Permit review;
3. Limited studies in which numerous areas are being evaluated in a very general way, such as early planning studies;
4. Studies in which only a few habitat variables are expected to change;
5. Studies in which only one or a few species are of interest. Such a study using HEP is currently being conducted to identify existing sandhill crane habitat along the North Platte River and to identify management activities that could be used to increase available habitat; and
6. Coal leasing studies in the Northern Great Plains so that wildlife values can be integrated into coal lease planning considerations.

An area that will require greater coordination and cooperation to conserve our aquatic resources is that of Federal water rights. The Federal Government is one of the leading users of water in the West. Demand for water for projects carried out on the large tracts of Federal land sometimes competes with other public and private claims upon the same water. Over 60 percent of the average annual water yield in the West is from Federal reservations.

This also has been an area of changing policy. Nearly four years ago, the previous Administration adopted and supported a theory of law for obtaining Federal rights in unappropriated water, the so-called "non-reserved water rights" theory. According to this theory, the Federal Government has the right to use unappropriated water on Federal land—reserved or not—without regard to State substantive or procedural water law whenever the water was needed for an authorized function of the Federal agency. As might be expected, the "authorized functions" envisioned were quite broad.

In late 1981, the Department of the Interior repudiated the prior Administration's opinion. As Secretary James Watt put it, the new Interior Department position "means federal land managers must follow State water laws and procedures *except* when Congress has specifically established a water right or where Congress has explicitly set aside a federal area with a reserved water right. If they need more water for their programs, they must take place in line like any citizen and let State authorities decide."

Interior agencies are now acquiring water rights in the same fashion as anyone else, by complying with State procedural and substantive water law. It is possible that in the long-term this policy change may result in protection of instream flows for fish and wildlife by having these adjudicated water rights established.

As you can see by these few examples, there are many opportunities within the framework of existing and newly adopted policies to improve our efforts to protect and conserve water and wetland resources. We also can expect that through legislative means or agency directives additional State and Federal policies will be developed.

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Important Indian Water Rights Cases of 1982–1983

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Introduction

The purpose of this address is to summarize three cases pending before the Supreme Court this term, including the recent decision in *Arizona* v. *California,* and the United States' position in those cases. The results of two trials that have recently been concluded, *Wyoming* and *Aamodt* will also be discussed.

Cases Pending in the Supreme Court

There are three Indian water rights cases before the Supreme Court this term which will likely have far-reaching impacts on Indian water rights litigation.

A. *Arizona* v. *California*

Argued December 8, 1982, decided March 30, 1983.

1. *Background*

This suit to adjudicate water rights on the Colorado River was first filed in 1952.

The 1963 opinion and 1964 decree awarded water rights to the five Indian reservations based on the number of practicably irrigable acres on the reservations. The decree awarded approximately 900,000 acre feet of water per year for the five reservations on the Lower Colorado River Basin.

2. *Issue and United States' position in this most recent decision.*

The United States in 1977 moved to correct the 1964 decree to include certain "omitted lands" and lands within the now finalized boundaries of the reservations. The Tribes intervened.

a. *"Omitted Lands" Issue*

The 1964 decree did not include certain lands, presently determined to be irrigable, because the United States did not make a claim for them at the time. The 1964 decree provided for "amendment or further relief" and the United States and the Tribes argued that this provision was intended to allow corrections such as the addition of these omitted lands.

b. *"Boundary Lands" Issue*

In 1964, the boundaries of the five reservations had not been finally established. The 1964 decree provided for "appropriate adjustment" of the water rights decreed in the event that the boundaries are "finally determined." The present boundaries of these reservations have now been fixed by orders of the Secretary of the Interior, and the United States claimed water for additional irrigable acres within these boundaries.

3. *Special Master's Report*

Senior Court of Appeals Judge Elbert P. Tuttle, appointed as Special Master, issued his report on February 22, 1982.

His report held that both "omitted lands" and "boundary lands" should be awarded water rights and that the 1964 decree should be amended accordingly. He awarded 320,000 additional acre-feet for these lands, approximately, 60 percent of the United States' claim.

4. *Supreme Court Opinion*
   a. Decided March 30, 1983.
   b. Rejected the Special Master's Report almost entirely and upheld the State's objections.
   c. *"Omitted Lands" Issue*

   The Court sustained arguments of the States that it is too late to raise the claims for "omitted lands."

   Rationale:

   Interest in finality even though *res judicata* does not technically bar the claims.

   States have relied on the 1964 decree in planning their future water supplies.

   Absent actual conflict of interest between United States and Tribes, Tribes are bound by actions of United States acting as their trustee.

   d. *"Boundary Lands" Issue*

   The Court agreed with the States that, as to boundaries set by Secretarial order, they were determined *ex parte* and without an opportunity for the State to object. The Supreme Court declined to find these boundaries as final and left open the award of water rights to those reservations until the boundaries are judicially determined.

   The Court agreed with the Special Master's award of water for the land within reservation boundaries which had been judicially determined since the 1964 decree.

5. *Comment and Implications*

This decision is clearly adverse to the interests of the Tribes in this case since the Tribes are thus bound to the inaccuracies of the 1964 decree, even though they were never joined as parties.

It may foreshadow the Sureme Court's decision in *Truckee Carson Irrigation District* v. *United States* because of the Court's reluctance to reopen prior water rights decrees. *Truckee Carson Irrigation District* is distinguishable, however, because the United States had an actual conflict of interest by representing the Tribes and the irrigation project in the prior decree.

This case demonstrates the importance of tribal participation in suits where the United States exercises its right and obligation as trustee to represent the Tribes. Tribes which refuse to participate may be bound in the future from attacking decrees already entered.

B. *San Carlos* and *Adsit* Cases

Argued March 23, 1982.

1. *Background*

The *San Carlos* group of cases arose in Arizona while the *Adsit* group of cases arose in Montana. Both groups of cases present the issue of whether state or federal courts will adjudicate Indian water rights.

This issue has been addressed by the Supreme Court in *Colorado River*

Water Conservation District v. *United States (Akin)*. The Court held in *Akin* that under the McCarran Amendment, state courts could adjudicate Indian water rights in general stream adjudications if certain factors governing "wise judicial administration" were met. These factors included the policy of avoiding piecemeal litigation and whether a suit had been brought in federal court and how far it had progressed.

2. *Issue*

The *San Carlos* and *Adsit* cases differ from *Akin* in that the Montana and Arizona constitutions and enabling acts expressly disclaim jurisdiction over Indian lands. The question is whether these disclaimer clauses disable the state courts from adjudicating Indian reserved water rights.

3. *The United States' Position*

The position of the United States is that federal courts should adjudicate Indian water rights because they are federally guaranteed rights and because of the long history of federal judicial protection of Indian rights.

However, we argued that if the United States or a Tribe did not move promptly to adjudicate Indian water rights in federal court, then state courts could properly proceed and adjudicate such Indian water rights. We took this position because one of the principal purposes of the McCarran Amendment was to prevent the United States from frustrating state efforts to adjudicate all water rights by refusing to participate in their adjudications. In addition, this position is consistent with the factors governing "wise judicial administration" set out in *Akin.*

4. *Importance of This Decision*

However the Court decides this case, it will cause a veritable flood of litigation in disclaimer states which have stayed water adjudications pending this decision.

The decision will directly affect all disclaimer states including most of the western states with significant Indian populations.

Hopefully, the Court will resolve these questions and provide some certainty as to jurisdiction in water adjudications.

C. *Truckee Carson Irrigation District* v. *United States*
(Pyramid Lake)
Argument set for April 28, 1983

1. *Background*

In 1944 a decree was entered in *United States* v. *Orr Ditch Co.* which adjudicated the water rights for the Truckee River. The United States participated on behalf of both the irrigation project and the Indian tribe whose interests did not appear at the time to be in conflict. The Tribe and the United States now seek to reopen that decree to assert claims for water to protect the tribal fishery in Pyramid Lake, the level of which has been declining in recent years.

2. *Issue*

Whether the 1944 *Orr Ditch* decree may be reopened to allow the United States and the Tribes to assert reserved water rights for fishery purposes which were not addressed in the 1944 decree.

3. *The United States' Position*

The United States agrees with the Ninth Circuit opinion holding that the decree may be reopened to consider the claims of reserved water rights for fishery purposes because it was not decided in the 1944 decree nor were the interests of the irrigation district viewed as adverse to those of the Tribe at the time the 1944 decree was entered. Thus the legal doctrine of *res judicata* does not apply.

4. *Analysis*

   The decision in *Arizona* v. *California* refusing to reopen a 1964 decree to add claims for water not considered in that decree is not favorable to the United States' and Tribe's position in this case.

   However, the two cases are distinguishable because although in both cases the United States represented tribal interests, the United States represented conflicting interests in the *Orr Ditch* decree, but there was no such conflict in *Arizona*.

Water Rights Cases Decided at the Trial Level

A. Wind River Indian Reservation, Wyoming.

1. *Background*

   This is a general stream adjudication initiated by the State of Wyoming to determine all of the water rights in Water Division Number 3, the Big Horn drainage basin, pursuant to a Wyoming statute enacted on January 22, 1977. The litigation was commenced two days after enactment of the legislation. On February 22, 1977, the United States removed the case to federal court; subsequently, however, the case was remanded to state court by Judge Kerr. The government then filed a motion to dismiss with the state court, but this motion too was unsuccessful. The United States was successful, however, in objecting to the appointment of the State Board of Control to act as a Special Master, and on May 29, 1979, Judge Joffe appointed Teno Roncalio of Cheyenne, Special Master.

   By agreement of the Special Master and the parties the case was scheduled to proceed in three phases. Phase I was the quantification of the reserved water rights of the Shoshone and Arapahoe Tribes of the Wind River Reservation; Phase II, the "non-Indian" federal reserved rights; and Phase III, rights held under state law (including rights held by the Tribe, individual Indians, or the United States under state law rather than by virtue of the reserved water rights doctrine).

2. *Trial and Special Master's Report*

   Trial in "Phase I," the Indian reserved rights, began in January of 1981, and final testimony was presented in January of 1982. Proposed findings of fact and conclusions of law were submitted by the parties on April 7, 1982, and argument on these proposed findings and conclusions took place in May. In January of 1983, the Special Master issued his Report, which was generally favorable to the Indians.

   In the proposed findings filed by the United States, we requested that the government, on behalf of the Tribes, be awarded the right to divert 572, 160 acre-feet of water annually in order to permit the irrigation of the irrigable trust lands on the reservation. The Special Master's recommended decree awards the government 477,000 acre-feet per annum and includes an award of water to irrigate Indian owned fee lands—a claim not made by the United States but pressed by the Tribes who had intervened. We were also awarded substantially all our claims for livestock water and water for municipal and industrial purposes. Additionally, we were given 60 percent of the maximum historic flows in certain stream reaches where instream flows are necessary to preserve the aesthetics of the area and approximately 50 percent of the instream flows we claimed in certain reaches of the reservation streams to protect the fishery habitat.

3. *United States' Exceptions to Special Master's Report*

   The Special Master also decreed that only 10 percent of the "future project" lands—that is, lands which are not now irrigated but which could be irrigated if new irrigation projects were constructed and for which a water right was claimed by the United States—could be brought into irrigation in any decade. In our view, this restriction, and other less onerous restrictions, are outside the scope of the Special Master's mandate and not justified by the law or the record in this case.

   The parties filed exceptions to the Special Master's Report on March 18, 1983, and a hearing on those exceptions is scheduled for April 18, 1983.

   The State and the United States were able to come to an agreement on the non-Indian federal reserved rights, and the court adopted a stipulation agreed to by these parties in February of 1983, after a hearing in which no objection to the stipulation was voiced. Hearings on Phase III—the rights held under state permits or certificates—have not yet been scheduled.

B. *State of New Mexico* v. *Aamodt, et al.,*

1. *Background*

   This case was brought by the State of New Mexico to adjudicate the waters of the Nambe and Pojoaque River basins. The United States intervened in its own right and on behalf of the Nambe, Pojoaque, Tesuque, and San Ildefonso Pueblos. The Pueblos have also intervened in their own right. The federal court assigned the case to Special Master Edward L. Yudin who proceeded to hear the Indian claims first.

2. *Special Master's Report*

   On November 23, 1982, the Special Master filed his findings and conclusions with the court. Specifically, the Special Master found that the Pueblos had a senior priority to water over other non-Indian water users, based on the practicably irrigable acreage on each Pueblo land grant. The Master referred to Spanish law and noted that under Spanish law water rights attach to Pueblo land grants in a quantity sufficient to satisfy the needs of the Pueblo. In particular, the Special Master found that "the evidence supports the Pueblos' contention that their water rights are immemorial in priority. . . ."

3. The United States has filed its exceptions to the Special Master's Report with the Special Master and we are awaiting his amended findings.

Conclusion

There is little that one can say with certainty about the future course of litigation involving Indian water rights except that the Supreme Court's decisions this term will have a dramatic effect on the shape of future litigation. The *Arizona* v.

California decision may provide some insight as to the reopening of prior water rights decrees. The *Adsit* cases will hopefully decide the jurisdictional issues which have plagued Indian water adjudications since the *Akin* decision. For its part, *Pyramid Lake* will hopefully shed some light on the effect of tribal absence from water adjudications.

Instream Flow Recognition and Protection under Arkansas Water Law

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There are over 20,000 miles (32,186 km) of permanently flowing streams in the State of Arkansas according to the Arkansas Natural and Scenic Rivers Commission. This indicates the relative abundance of water in the state. Arkansas' statewide rainfall average is approximately 48 inches (122 cm), and only occasionally are severe droughts experienced. Two major rainfall shortages, one in 1957, the other in 1980, created such social and economic strife that the Arkansas General Assembly reacted. Enabling legislation was passed in 1957 (Act 81 of 1957), creating the Arkansas Soil and Water Conservation Commission [Ark, Stat. Ann. 9–803]. In 1945, the citizens of Arkansas ratified Amendment 35 to the State Constitution, providing for the Arkansas Game and Fish Commission. Both agencies were given responsibilities to protect instream flow values. Soil and Water Conservation Commissions's (SWCC) mandate was to insure adequate water for downstream riparian landowner needs (May 1981). The Game and Fish Commission's (GFC) purpose was to provide suitable habitats for the propogation of fish and wildlife [Arkansas State Constitution, Amendment No. 35, Sec. 8]. Other state agencies have recently been created to deal with this matter from the perspective of water quality and the preservation of natural and cultural heritage typically found along the State's outstanding river reaches.

Arkansas is typically considered a wet state, and the early growth of water law dealt with litigation brought about by the impact of manmade obstructions upon adjacent landowner's property (May 1981). Because of a reasonably assured seasonal abundance of water, the State historically adopted a riparian water law doctrine of reasonable use (Looney 1982). With the passage of Act 81 of 1957, a somewhat mixed doctrine of riparian and appropriation law was recognized, allowing for a "fair share" allocation system to be in effect during severe shortfalls [Ark. Stat. Ann. 21–1308].

Water law typically reflects the relative abundance of the resource and the attitudes of the state's constituents. This is often difficult to assess in regions where one region may be in a drought while others are, at the same time, being flooded (May 1981). Because of the mixed topography of Arkansas (Ozark Uplift, Coastal Plains, and Delta), there has been a great deal of difficulty in combining the political attitudes to create an effective statewide water policy. In 1981, the Arkansas Water Policy Task Force Commission attempted to effect a policy through the Governor's approval of the *Arkansas Water Policy*. Beyond calling for the increased use of conservation, nonstructural flood control, and flood plain management, and providing for lotic water recreation, this body was one of the first to hint at the need to establish instream flow values for all uses. This would include those consumptive and nonconsumptive instream values. (Jackson et al. 1980).

The classical definitions of beneficial uses of water have in the past been confined to the consumptive needs of municipal, agricultural, or industrial users. When made, fish and wildlife needs have been defined by the 7-day, 10-year low flow

($7Q_{10}$). This institutionally recognized level has recently undergone challenges (Lamb, pers. comm.). When government bodies appropriate the $7Q_{10}$ for fish and wildlife, it legally establishes as an annual event a drawdown to levels defined as a one-in-10 year occurence. Recognizing the dynamics of ecosystems, the effect of such water resource management upon fish and wildlife populations characteristic of a river reach would be disastrous. The natural selection of floral and faunal forms would benefit those species capable of thriving in conditions so atypical of an affected reach's hydrologic history.

In Arkansas, the question surrounding instream flow value determinations may not be if they should be made, but who has the authority to make them. This point is presently debatable. Amendment 35 to the Arkansas State Constitution, section one, states:

> The control, management, restoration, conservation and regulation of birds, fish, game and wildlife resources of the State . . . [and] the administration of the laws now and/or hereafter pertaining thereto, shall be vested in a Commission to be known as the Arkansas State Game and Fish Commission. . . .

Section eight states:

> The fees, monies, or funds arising from all sources . . . shall be expended by the Commission for the control, management, restoration, conservation, and regulation of the birds, fish management, restoration, conservation and regulation of the birds, fish and wildlife resources of the State.

Implicit in these two sections is the constitutional authority for GFC to establish instream values beneficial to the conservation of fish and wildlife populations. This has been officially stated in comments of the GFC Director, Steve Wilson, to the Arkansas Water Codes Study Commission in 1982. The GFC is presently studying the various instream flow determination techniques extant. No results are presently available from their efforts.

Two pieces of legislation define the responsibilities of riparian landowners in providing adequate water and migratory paths for fish. Instream flows are recognized in Ark. Stat. Ann. 47–515 which reads in part: "[It is] Unlawful for any person, firm or corporation to lower the natural stage of any body of water to a point whereby the existence of fish is thereby endangered."

Two severe droughts have prompted the consideration of water law legislation. Act 81 of 1957 created the Arkansas Soil and Water Conservation Commission. This Commission was empowered with the authority to deal with all aspects of water and water resource development [Ark. Stat. Ann. 9–803]. Among its duties, SWCC issues permits for dams and allocates water during shortfalls. Statutes provide for the operation of dams to be in a manner so as to provide ". . . a quantity of water fixed by the [SWCC] Commission as necessary to preserve, from time to time, below the dam, the flow of the stream involved at a rate approximately the flow it would maintain if the dam had not been constructed [Ark. Stat. Ann. 21–1306 (C)]." The rights of downstream riparian landowners are preserved.

During rain shorfalls, the SWCC ". . . may allocate [water] . . . in such a manner that each may obtain his fair share [Ark. Stat. Ann. 21–1308]." The law further establishes an order of preference, being ". . . (i) sustaining life (ii) maintaining health, and (iii) increasing wealth."

The drought of 1980 saw a new problem arise. The GFC had not established criteria for instream flow determinations. Furthermore, case law was not clear as to the definition of a "fair share" of water (Saxton, pers. comm. 1982). In addition, there was increased political pressure to deal with the potentially disastrous groundwater situation in the Grand Prairie of the State. This vast rice producing region was experiencing a rapid decling of groundwater levels according to the U.S. Geological Survey. The additive effect of these situations culminated in the creation of the Arkansas Water Codes Study Commission in 1981. This group was charged with the review of existing water law and, if necessary, drafting such legislation at it saw fit.

At the present time, the Arkansas Water Resources Act's fate hangs in the balance, and it appears doomed. The proposed bill, House Bill (H.B.) 60, attempts to move Arkansas from riparian to appropriation doctrine, while "grandfathering" the rights of the latter for an established period of time. Section two of H.B. 60 declares that ". . . protection and procreation of fish and wildlife; maintenance of proper ecological balance and scenic beauty; protection of water quality and the preservation and enhancement of the waters of the State for navigation, public recreation, municipal users, and public water supply . . ." shall be the focus of the act. Section 9(b) stipulates that ". . . navigation, fish and wildlife and the maintenance of water quality standards shall have priority over all beneficial uses." The reason for the apparent demise of the new code is language dealing with the permitting (appropriation) process and the issue of groundwater (*Arkansas Gazette* 1983).

The Arkansas Department of Pollution Control and Ecology (ADPC&E) is the designated water pollution control agency of this state (May 1981). Because of this role and ADPC&E's legislative mandate, it can have a strong role in insuring that adequate flow values are achieved. ADPC&E has recently requested input from other water resource related agencies concerning the potential water quality degredation that could result from excessive water withdrawls along the lower Little Red River. This precedent shows the intention of ADPC&E to monitor this situation.

In addition to a myriad of other agencies that monitor water volumes and quality for public health and economic reasons, the Arkansas Natural and Scenic Rivers Commission stands alone in its efforts of stream preservation through the coordination and activity of local riparian landowners. The Commission's mission is to insure that the natural and cultural values of outstanding river reaches have full recognition and consideration in plans for water resource development. Implicit in the enabling legislation, Act 257 of 1979, the Commission may help establish minimum instream flow regimes to conserve those natural and cultural characteristics identified by local conservancy groups.

In summary, the legal mechanisms needed to establish instream flows above a 7 day-Q_{10} seem to exist through that constitutional and statutory law defining the duties of the Arkansas Game and Fish Commission. The Soil and Water Conservation Commission's enabling legislation provides for instream flows through dams, which are to assure those flows existing before the construction of the hydraulic control. Navigation is controlled through inter-governmental contracts. The Department of Pollution Control and Ecology monitors water quality; instream flows have been recognized by that agency to have serious water quality management implications. Finally, the Natural and Scenic Rivers Commission may initiate legislation to protect instream values which define the natural values of outstanding river reaches.

The major obstacles that stand in the way of a definite instream flow policy for Arkansas are need, money for research, clarification of responsibilities, and attitudinal changes at both the institutional and public levels. Need for a comprehensive, effective water doctrine and an underlying fear of Arkansas' excess water being used to recharge the Ogallala-High Plains Aquifer of the Great Plains is the present motivation for the water code changes being considered. Clarification of the law is needed since the GFC may have constitutional authority for its instream value determinations, yet similar responsibility has been statutorily granted to SWCC. Attitudinal changes must be attained before adequate instream flow values for all nonconsumptive uses will be widely recognized. More environmental education is needed to broaden public perspective and prevent environmental backlash when instream values for fish, wildlife, and water quality seem to be given priority over economic needs.

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Natural Area Selection and Management

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State Natural Area Programs

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State natural area programs had their origin in the Midwest in the 1950s and 1960s. They evolved here partly because this was a center for the developing field of community ecology, but primarily because it was the nation's region of greatest landscape modification. By the 1950s, it was obvious that if the option of studying a natural ecosystem in the "corn belt" in the future was to be retained, something would have to be done. By the 1970s, as use pressures increased on all lands, the realization that the survival of natural ecosystems depended on positive action spread nationwide. At the present time, over half of the 50 states have natural areas programs.

As the first natural areas programs evolved, leadership for them naturally fell to state government. Federal land holdings were meager in the Midwest and, while political support for such programs existed in states with a critical need, national support was lacking. The early precedent of state responsibility for natural area preservation has survived in the age of national environmental awareness because it offers an effective and practical approach with proven success.

The objective of most state natural areas programs can be summarized as the preservation of a state's natural communities, species, and landforms for public benefit. Some programs include geologic phenomena of special scientific and educational value as well. Public benefit includes provision of areas for casual nature hikes and study, formal educational use and scientific research. Use is limited to activities compatible with the specific site's preservation needs.

The elements of a typical state program consist of a protective mechanism, an inventory/classification effort, an acquisition/preservation effort, and a management program.

The protective element is present in many but not all state programs. Typically, it is a state statute providing permanence and protection for formally dedicated or designated areas. Since natural areas are non-renewable, some protection against destruction of areas at the whim of administrators has been deemed desirable by many state legislatures. Some statutes also protect against disturbance to areas by publicly regulated developments such as highways and pipelines. Formally dedicated preserves systems are usually under the control or guidance of a board or commission of citizens interested in natural areas.

Dedication of preserves is generally open to any landowner. Thus a "state" system might include lands owned by counties, cities, universities, private individuals, and federal agencies, as well as state conservation agencies. Dedication is made binding by a recorded legal document equivalent to an easement in the public's behalf of development and most use rights. Some states offer tax exemption or reduction for private owners who dedicate.

Some state programs lack a strong statutory basis and are established administratively. Such programs may also have advisory boards, but depend on existing authority for their state agencies to designate, protect, and manage their areas. Such programs are usually also open to a wide variety of public and private landowners.

Classification and inventory programs vary from state to state, but share the goals of systematically classifying the state's natural features and locating and documenting significant occurrences of them.

The classification system most commonly used is an approach which divides a state into regions of similar physiography and biota. This "natural divisions" approach is supplemented with natural community or vegetation type classifications.

Endangered and threatened species of concern to state programs include federally listed species and species under review for federal listing. These species are almost always supplemented with a state list. Some states have an official list resulting from a state statute, but probably the most common approach is a list compiled by consensus of panels of experts on the state's flora and fauna. Lists of geologic and landscape phenomena, if used, are derived by the state's geologists.

Inventory efforts typically begin by compiling known or available information. Initial field work centers around confirming reported occurrences and searching for old collection localities. As the inventory matures, emphasis shifts to systematic searches of the state for communities and species. Initial emphasis is usually given to types and species for which no current occurrences are known. Some states have completed systematic searches of their entire state for undisturbed ecosystem remnants, but this is the exception rather than the rule. Species searches are usually prioritized on degree of presumed endangerment.

Inventory data is frequently computerized and is used to guide protection and preservation efforts. Its primary use is guiding preservation efforts, such as land acquisition and designation, but it also provides a basis for permit reviews and environmental impact statement preparation. Inventory efforts are sometimes housed in state agencies separate from the staff responsible for preservation and management of the natural areas system. This is sometimes the result of limited available funds, but also reflects the broader applicability of inventory data for planning.

The preservation program effort is directed at dedicating and designating areas into the formal system of preserves, purchasing of selected tracts of land, and various less than acquisition options to land protecton. Some of the options include conservation easements, cooperative agreements, and state registries. This latter program is becoming popular as a means of getting a low level of protection at low cost by negotiating a non-binding agreement between the state and private landowner. In exchange for recognition in the form of a plaque or certificate, the owner gets management advice. The state gets formalized contact with the landowner and sometimes the right of first refusal should the land be put up for sale. All preservation and protection efforts are usually limited to areas that qualify for the inventory. Priority is usually given to communities over species. Acquisition and other preservation efforts are frequently in close cooperation with private sector programs such as that of The Nature Conservancy.

Management advice and assistance is usually a service offered by the state in negotiating protection and preservation agreements with both public and private landowners. It is usually authorized by statute for designated or dedicated areas. It is an incentive for federal and local governments which may lack natural areas expertise on their staff.

The management program deals with vegetation and wildlife management, facilities development, and maintenance and regulation of people. Some programs include interpretive and educational efforts. Management staff tends heavily toward botanists and foresters as vegetation management is perhaps the biggest part of the job. Management is usually guided by a master plan approved by the agency, owner, and board or commission.

While the program staff manager prescribes and participates in preserve management, many other disciplines in the conservation agency as well as private citizen volunteers are frequently involved. In probably the majority of state programs, management responsibility remains with the owner whether that be an agency of local, federal, or state government or a private owner. Even where the area is owned by a state conservation agency, management responsibility may remain with the Parks Division or other administering unit. The natural area manager is thus frequently more of a management planner and adivsor than a direct manager. There are a few notable exceptions to this general rule.

Vegetation management consists primarily of managing for certain successional stages and for control or elimination of noxious exotic species. Successional management might involve prescribed burning for prairie maintenance. Exotic control could involve application of herbicides or water level manipulations to control problem plants. It usually also includes monitoring programs to detect the effect of the management being applied or long term ecological shifts in vegetation. Wildlife management may involve habitat enhancement for an endangered species.

Facilities on most state natural areas are the minimum to provide for use while protecting the area's character and the visitor's experience. Small parking areas and trails are the most frequent developments. These are typically augmented by boundary signing and may include interpretive signing. A few state preserves boast nature centers.

Unauthorized use, such as hunting and off road vehicle use, is a common people management problem. Countering it generally involves coordination with site managers and law enforcement authorities. Few state programs provide their own law enforcement. Regulation of research on preserves is usually handled by a permit system and may involve approval by the citizens board as well as program administrators.

State natural areas programs frequently function as catalysts. They provide information and expertise to a variety of agencies and landowners to reach their goal of preserving examples of their state's natural diversity.

Private Natural Area Programs: An Overview

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Private natural area programs have been and continue to be established because many citizens believe private organizations can best develop and apply certain methods to protect significant elements of our natural world. Well-designed and properly executed private natural area programs should complement and supplement the work of government agencies. The following paragraphs discuss the primary ways that private programs should enhance the overall natural area protection effort in the United States.

Building a larger and better informed national constituency for the support of natural area protection can be aided by private groups. Newsletters and magazines, new member mailings, field trips, and exciting citizen based initiatives, all help increase the number of people who are aware of and/or concerned about natural areas. A national constituency can translate awareness and concern into favorable policy decisions and dollars by gaining the attention of organizations with a national focus (federal government, corporations, foundations).

Local constituencies also are important. This could mean building support for a proposed natural area with adjacent landowners, changing a zoning ordinance, or starting a community tradition by involving citizens in an annual volunteer day to mend fences, burn a prairie, or conduct a bird census. Local contacts are a mainstay of private natural area organizations.

These local and national constituencies are "high quality." Since private groups normally require annual dues and often request further contributions of money and time, their members are more committed to the cause of natural area protection than the general populace. This commitment is an asset since the members of these groups can be relatively easily contacted and organized for efforts like letter writing campaigns and fundraising events.

Private programs offer the advantage of specialization. Specific measureable goals allow concentration on the job at hand without the distraction of accommodating multiple uses. Limited resources can be directed to a scientifically determined priority list of sites. Management of natural areas can be geared to protecting rare and endangered plants and animals without including sometimes conflicting provisions for game habitat or picnic grounds.

A measure of insurance is provided by private natural area protection. Recent government policies and funding limitations have in part been compensated for by private efforts. While private groups can never hope to marshall the resources of government agencies, there is great value in the continuity being maintained in information gathering and contacts with owners of the most critical lands.

Another way that private groups provide insurance is by deed restrictions or reversionary interests in properties transferred to government agencies. If agency policies change to such an extent that a threat to the natural area quality of the transferred property develops, the private group will have the ability to remove the threat by enforcing the deed restrictions or exercising its reversionary interest.

Survival depends on success. This is especially true for private groups that must raise every dollar they spend. Each time a fundraising call is made, a documented record of success must be available or no money will be forthcoming. This harsh environment forces innovation and hard work and does a great deal to guarantee that natural areas are protected. The need to succeed to survive is a motivator most prevalent in private groups with full-time staff.

While money is always in short supply, private groups can tap funds that would otherwise not be available for natural area programs. Maintaining contacts with potential donors (corporations, foundations and individuals) is something government is not set up to do. Many trustees and members of private organizations are skilled fundraisers and have influence and knowledge not available to government natural area managers.

It is always useful to have an outside voice of support for a project or program. The likelihood of a state conservation agency getting a special appropriation to acquire natural areas would be increased if credible private groups second the motion. It is often easier and more effective to complement the work of others.

Private groups offer an advantage in speed of action especially in financing land purchases when the landowner's requirements do not match a government budget cycle. Additionally, the bias some landowners or other potential natural area supporters may have against government agencies in general can often be mitigated by working through a private group.

Perhaps the greatest reason for encouraging a variety of natural area programs (public and private) can be found in one of the major arguments for protecting natural areas themselves. This argument states that the value of our natural world is found in its diversity and that this diversity is responsible for the smooth functioning of our natural world and also holds the key to many of man's problems, known and yet unknown. Private programs assist the overall natural area protection effort by adding an element of healthy competition that urges even better performance from everyone involved. A diverse pool of groups and individuals dedicated to the protection of natural areas holds the promise of new fundraising techniques, advances in land protection and management, and new legal and tax tools. Without this diverse and dynamic pool of talent, natural area protection programs would soon become stale and ineffective. There is a place and a need for public and private natural area programs. It's time to get on with the job at hand before it's too late.

Natural Area Selection and Management: U.S. Forest Service Programs

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Origin of the Forest Service Program

The research natural area program of the Forest Service had its genesis in 1927. It followed by several years an Act of Congress dated August 10, 1912 (SP Stat., 297) that directed the Secretary of Agriculture to select, classify, and segregate lands within the boundaries of the National Forests that might be opened to homestead entry. Some 14 years later, in July of 1926, a 4,500 acre (1,822 ha) tract of land adjacent to the Mt. Lemmon Recreation Area was examined by Forest Ranger J. A. Frieborn to determine if it was sutiable for homesteading. It was classified as not being chiefly valuable for agriculture and, therefore, not subject to the provisions of the Act. However, the lands were identified as having value for timber production and stream flow protection. They also were identified as containing cover of such a character that it was considered in the public interest to retain them in their natural state for study by the Natural Historical Society of Tucson, Arizona and other scientific organizations. Accordingly, on March 23, 1927, then Acting Secretary of Agriculture R. W. Dunlap designated that area on the Coronado National Forest in Arizona as the Santa Catalina Natural Area with all lands therein contained to be managed to permit scientific studies of the forest growth. Thus was established the first Forest Service Natural Area. The designation was later changed from natural area to research natural area (RNA), as it is known today.

The number of Forest Service research natural areas has increased slowly but steadily over the past 55 years as shown in Table 1. Today we maintain a network of 148 RNA's. That number, though impressive, does not represent all of the forest, shrubland, grassland, alpine, aquatic, geologic types and other natural situations with characteristics of scientific interest and importance in each of the Forest Service Regions. We are working toward complete representation of these types and, where possible, to introduce a measure of redundancy into the RNA network to insure against catastrophic loss.

The rate of establishment improved somewhat over the past decade due primarily to the environmental movement, but it is still far below our potential. We expect the rate to markedly jump when Forest Plans are completed and approved. These plans specifically identify prospective sites for RNA's that will be covered by the environmental assessment for a particular forest. This means that prospective RNA's held in abeyance while Forest and Regional Plans are prepared will likely be submitted upon approval of these Plans. We expect a marked influx of proposals when these plans have been completed and approved in 1983 and 1984.

Extent and Purpose of the Forest Service RNA Program

Government agencies are governed by regulations, and the Forest Service is no exception. Regulation L-20 contained some of the original language that described

Table 1. Summary of Forest Service RNAs by year of establishment

Year	No.	Year	No.	Year	No.	Year	No.
1927	1	1942	3	1955	1	1970	4
1931	4	1943	3	1956	1	1971	11
1932	3	1944	1	1957	1	1972	7
1933	3	1945	1	1958	1	1973	15
1934	1	1946	1	1960	1	1974	5
1935	5	1947	3	1962	1	1975	3
1936	1	1948	1	1963	3	1976	3
1937	4	1949	1	1965	3	1977	8
1938	2	1950	2	1966	3	1978	3
1939	1	1951	4	1967	1	1979	5
1940	1	1952	1	1968	3	1980	3
1941	1	1953	1	1969	4	1981	5
						1982	4
						TOTAL	148

the extent of the proposed natural area network and the purpose for which natural areas were to be established. It stated that "A sufficient number of natural areas would be established to insure the preservation of virgin areas typical of important forest conditions in the United States and permitting continuity of study to climax types. Probably a dozen such areas will be required in each forest region. If, however, a forest type is adequately represented in some other permanent form of reservation such as a national park, duplication in a national forest may be unnecessary."

In effect this regulation charged the Forest Service with coordinating its efforts at establishing research natural areas with other land management agencies. As will be shown later, although the impetus for coordination waxes and wanes depending upon priorities set by the administration and the agencies themselves, in general the land management agencies have a good record.

The Forest Service has surpassed the number of natural areas originally envisioned without completing the network, but the distribution of existing areas is somewhat skewed (Figure 1). There are far more federally administered lands in the West than in the East. The western regions and experiment stations also have established about two-and-one-half times as many RNAs as have the eastern regions and stations, and those in the West also tend to be larger in area. Some of the success of those Forest Service regions and stations is owed to good cooperative working relations with land management agencies like the National Park Service and the Bureau of Land Management in the West and to a few dedicated individuals like Chuck Wellner, who, though retired, continues to work for the Forest Service as a volunteer identifying and establishing RNA's in Idaho.

As originally conceived and recorded in Regulation L-20, the purpose for establishment of Natural Areas was "Permanently to preserve in an unmodified condition areas representative of the virgin growth of each forest and range type within each forest region so far as they are represented within the national forests, to the

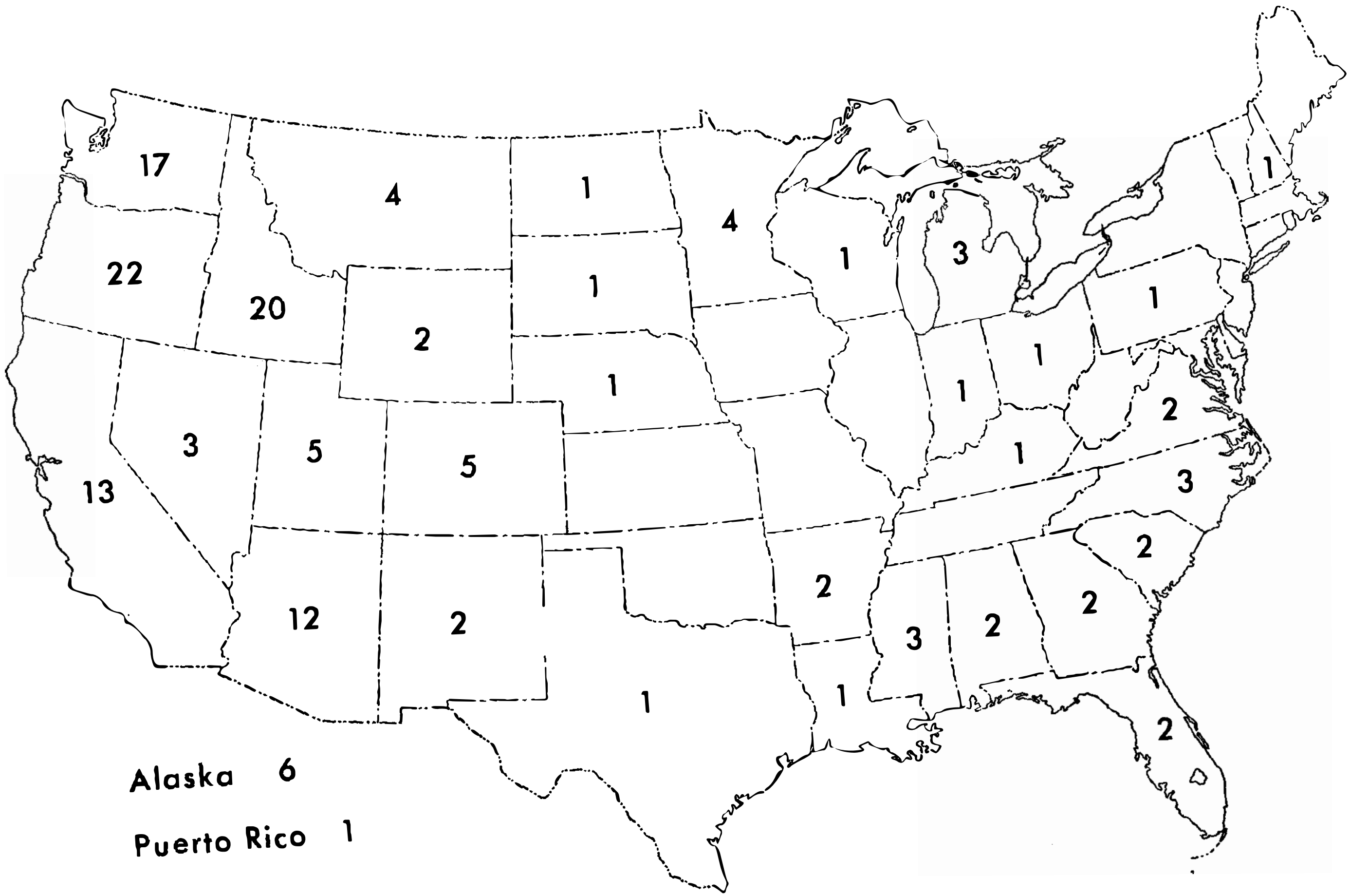

Figure 1. Distribution of RNAs by location.

end that its characteristic plant and animal life and soil conditons, the factors influencing its biological complex, shall continue to be available for purposes of science, research, and education."

Although the original purpose for the establishment of natural areas has not changed, it has been defined in more detail. RNA's are limited in use to research, study, observations, monitoring, and kinds of educational activities that are non-destructive and nonmanipulative, and that maintain unmodified conditons. These activities include:

1. Preservation and maintenance of natural diversity.
2. Protection against serious environmental disruptions.
3. Reference areas for the study of succession.
4. Monitoring environmental changes.
5. Controls for measuring effects of land management practices.
6. On-site and extension educational activities.

RNAs also have additional value for carrying out provisions of special acts such as the monitoring provison in the National Forest Management Act.

In its 1980 publication, the Society of American Foresters (SAF) identified 145 forest cover types. Eleven of these were not recognized previously. More than 80 of the 145 forest cover types are now represented in the Forest Service RNA network. Many are represented a number of times in more than one region or location while others are listed once or not at all. The reason for much of the variation and for having much of one type lies with the fact that in establishing a RNA an attempt is made to use natural boundaries, such as a small drainage or watershed. These areas often contain relatively small portions of forest types already contained in the RNA network. To exclude the small portion simply because it is already represented in our network might well jeopardize the integrity of a candidate watershed, consequently they are included. The forest cover types not now represented in our network are difficult to find in the pristine condition required for qualification as a Forest Service RNA. The increased importance and utility of RNA's for monitoring impacts of resource management activities on site productivity promises to provide the impetus needed to complete the network. Tables 2 and 3 illustrate the number of representative areas we presently have in each SAF forest cover type and Kuchler type.

Selection and Management of Research Natural Areas

Within the Forest Service, selection and management of research natural areas is part of a continuing land and resource management planning process on the 190-million acres (77-million ha) of forest and rangeland and for the 155 national forests of the National Forest System. The process generally follows the sequence:

1. Forest plans identify situations, such as an area especially rich in natural diversity or one with an exceptionally fine example of a forest cover type in pristine condition, that should be reserved in natural areas.
2. Natural areas that include these situations are proposed.
3. Research activities planned for the area and for its administration are included in the Forest Plan (also included are specific directions for management and protection of the area).
4. Action to establish the proposed research natural areas proceeds after each proposal completes the planning process.

Table 2. Summary of RNAs by Society of American Foresters Forest Cover Types. (Note: Most RNAs contain more than one vegetative type.)

SAF Type	No. RNAs	SAF Type	No. RNAs	SAF Type	No. RNAs	SAF Type	No. RNAs	SAF Type	No. RNAs	SAF Type	No. RNAs
1	4	35	0	66	0	93	2	207	1	232	2
5	2	37	1	67	0	94	0	208	1	233	0
12	3	38	1	68	0	95	0	209	4	234	2
13	0	39	1	69	0	96	2	210	29	235	2
14	1	40	0	70	1	97	0	211	5	236	0
15	2	42	0	71	1	98	2	212	7	237	27
16	4	43	1	72	0	100	1	213	7	238	2
17	0	44	2	73	0	101	0	215	8	239	6
18	1	45	2	74	0	102	3	216	0	240	2
19	0	46	0	75	3	103	1	217	10	241	2
20	0	50	0	76	1	104	1	218	14	242	0
21	3	51	0	78	0	105	0	219	3	243	5
22	1	52	4	79	1	106	0	220	1	244	2
23	4	53	1	80	0	107	0	221	7	245	1
24	2	55	2	81	0	108	0	222	0	246	0
25	4	57	0	82	0	109	0	223	4	247	1
26	0	58	2	83	0	110	0	224	12	248	0
27	3	59	2	84	1	111	0	225	6	249	1
28	1	60	3	85	0	201	1	226	9	250	1
30	0	61	0	87	0	202	0	227	9	251	0
31	0	62	0	88	0	203	0	228	7	252	0
32	1	63	0	89	0	204	0	229	6	253	0
33	0	64	0	91	2	205	7	230	6	254	0
34	1	65	0	92	1	206	19	231	2	255	0
										256	0

Preparation of a report describing the area, justifying its candidacy for research natural area status, and proposing it for inclusion in the RNA network follows a detailed examination of an area. In general, areas proposed are large enough to provide essentially unmodified conditions in their interiors (usually entire small drainages or watersheds are sought), show no evidence of disturbance by man for at least the past 50 years, and, where practical, are established near manipulative research areas so as to provide a nonmanipulative counterpart. The report, which may also contain a plan of management for seral types, receives an intensive review by concerned Washington Office staff specialists and adminstrators before if is recommended for approval by the Chief.

Owing to the stringent requirements for selection and approval, seldom has an established Forest Service RNA been disestablished. We are proud of that record, and we intend to maintain and improve upon it.

The Forest Service is not alone in establishing RNAs, but among federal agencies it has the most dynamic program. The latest figures available show the following distribution of RNAs in the national network.

Table 3. Summary of Kuchler types in the Forest Service RNA Network.

Kuchler Type	No. RNAs	Kuchler Type	No. RNAs	Kuchler Type	No. RNAs	Kuchler Type	No. RNAs	Kuchler Type	No. RNAs
1	0	22	0	43	1	64	0	85	0
2	0	23	1	44	0	65	0	86	0
3	0	24	0	45	0	66	1	87	0
4	0	25	0	46	0	67	0	88	0
5	0	26	0	47	1	68	0	89	0
6	0	27	0	48	1	69	1	90	0
7	0	28	0	49	0	70	0	91	0
8	0	29	0	50	4	71	0	92	1
9	0	30	1	51	3	72	0	93	0
10	0	31	0	52	8	73	0	94	1
11	2	32	0	53	1	74	0	95	0
12	4	33	4	54	1	75	1	96	0
13	2	34	1	55	7	76	0	97	0
14	3	35	0	56	0	77	0	98	0
15	3	36	0	57	0	78	0	99	0
16	0	37	5	58	1	79	0	100	0
17	0	38	4	59	0	80	0	101	0
18	0	39	1	60	0	81	0	102	0
19	0	40	1	61	0	82	0	103	0
20	0	41	0	62	1	83	0	104	0
21	0	42	0	63	1	84	1	105	0
								106	0

Agency or Organization	*No. RNAs*
Fish and Wildlife Service	194
National Park Service	64
Bureau of Land Management	23
Department of Defense	4
Tennessee Valley Authority	4
Department of Energy	2
Bureau of Indian Affairs	1
The Nature Conservency	1
Forest Service	148
	441

The Federal Committee on Ecological Reserves, (FCER) chartered in 1974, under the joint leadership of the National Science Foundation and Council on Environmental Quality coordinates Federal activities with those of State and local governments, academic groups, and scientific organizations concerned with scientific reserves and experimental areas. As part of its commitment to the National RNA Program and to the FCER, the Forest Service in 1977 published the latest information on RNAs, which was compiled and summarized by The Nature Conservancy. The publication is entitled, "A Directory of Research Natural Areas on Federal Lands of the United States of America."

The forest Service has a strong and dynamic RNA program and a strong commitment to maintain or improve upon the record of our past performance.

Successes and Problems in State Natural Areas Programs

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Introduction

In 1977, Colorado was one of the first western states to pass legislation creating a state natural areas program. Although the younger western programs have benefitted from the successes and problems faced by the older eastern and midwestern programs, several differences exist between these programs. To put my comments into perspective, I will briefly describe these differences.

1. Although the state legislation creating the Colorado Natural Areas Program contains a broad legislative mandate to identify and protect quality and rare ecosystems and geologic phenomena in Colorado, the State has never appropriated more than $30,000 a year to the program, obviously not adequate to meet such a legislative mandate. Funding for the program has come largely from various federal and private agencies.
2. Over 34 percent of Colorado is managed by federal land managing agencies such as the Bureau of Land Management (U.S. Department of the Interior) and the U.S. Forest Service (U.S. Department of Agriculture), and 6 percent is owned by the State and managed for the greatest revenue. Percentages of public lands are even greater in other western states. Since the state program is concerned with identifying and protecting scientifically qualified natural areas statewide on both public and private lands, it is important for the state program to develop the cooperation of, and to coordinate natural areas efforts with, federal and state land managing agencies.
3. Elevational changes of over 9,000 feet (2,743 m) in Colorado create diverse ecosystems within the State ranging from shortgrass prairie in the eastern plains to alpine tundra in the Colorado Rockies, where 14,000-foot (4,267 m) peaks are common.
4. Colorado's legislature is a conservative one, not uncommon in western states. Both the State House and State Senate have a Republican majority. Therefore, the rights of private landowners and the right to free enterprise are protected strongly in Colorado.
5. Whereas many of the eastern and midwestern states have small remnants of relatively undisturbed native plant communities, Colorado has thousands of acres of Wilderness and Wilderness Study Areas, as well as National Forest System lands and Bureau of Land Management public lands which are managed for multiple use.
6. In general, the inseparable phenomena of the rapid growth of the state's population and the increasing development of the state's natural resources, such as coal, uranium, and oil shale, are considered favorable to economic development at the public and private level. It is impossible to protect, at a comparable rate, natural features threatened with irreversible change when there are

vast areas of Colorado not yet inventoried for rare species or for quality or rare ecosystems, and with such inadequate resources to do so.

Nevertheless, state natural areas programs have achieved successes in such an environment. The problems inherent in obtaining these successes, and the successes themselves, will be limited to the three most important issues facing state natural areas programs:

1. State legislation.
2. Program funding.
3. Coordination with other agencies.

State Legislation

As in many other states, the Colorado natural areas legislation contains a broad legislative mandate:

> . . . The general assembly hereby finds and declares that certain lands and waters of this state representing diverse ecosystems, ecological communities, and other natural features or phenomena, which are our natural heritage, are increasingly threatened with irreversible change and are in need of special identification and protection and that it is in the public interest of present and future generations to preserve, protect, perpetuate, and enhance specific examples of these natural features and phenomena as an enduring resource. It is the intent of this article to provide a means by which these natural features and phenomena can be identified, evaluated, and protected through a statewide system of designated natural areas. (Colorado Natural Areas Act 1977).

'Natural Area' as defined in the Act is:

> . . . a physical and biological area which either retains or has reestablished its natural character, although it need not be completely undisturbed, and which typifies native vegetation and associated biological and geological features or provides habitat for rare or endangered animal or plant species or includes geologic or other natural features of scientific or educational value. (Colorado Natural Areas Act 1977).

The successful aspects of the legislation are that it exists, it contains an important and broad legislative mandate, and it provides an ecological voice within and among state and federal land managing agencies within the State. Some potentially weak aspects of the legislation are:

1. The law does not give the Colorado Natural Areas Program the power of eminent domain, nor does it give the private landowner any tax advantages upon site designation. Scientifically qualified natural areas can only be registered and designated by the state program with the voluntary cooperation and approval of the private landowner or the public land managing agency. If a priority protection site, identified by the program's inventory or by other sources, occurs on property having a landowner not wishing to make a commitment to the State to manage his/her land to protect those elements of natural diversity of concern to the State, then the State cannot force the issue. It is possible, then, that the only known populations of a species of plant, for example, particularly if they occur on private land and/or if they are not populations of a federally listed species, may become extirpated even though the site and its importance to the State have been identified and justified. Therefore, site pro-

tection requires that the landowners be educated about the ecological or geological significance of the site in order to obtain their agreement to manage their land to protect its important scientific qualities.

2. The law does not give management authority to the program. All rights to the registered and designated properties remain with the landowner. Land or rights to land donated to, or purchased by, the program must be managed by a managing agency within the Colorado Department of Natural Resources. Although a lack of management authority makes it difficult to provide facilities and access for public use and to protect the natural qualities which initially identified the natural area, state management of the approximately 60,000 acres (24,300 ha) of natural areas in Colorado would be costly and unrealistic in these times of low federal and state funding for these kinds of programs.

Since the bill was passed in 1977 with a sunset clause requiring reauthorization of the program and the council by 1983 or the termination of the program by 1984, there is currently a bill in the Colorado legislature to reauthorize the existing legislation with minor housekeeping amendments. Although there was Council and Departmental discussion to propose strengthening amendments in the reauthorization bill, it was decided that such action might kill the program. The current law is much better for the natural resources and people of Colorado than no law at all. Now that Senate Bill No. 104 concerning the reauthorization of the Colorado Natural Areas Program is on its way to becoming law since it has passed out of the 32-member Colorado Senate with no opposing votes and 24 Senate co-sponsors, and has unanimously passed out of the House Committee, I wonder if we shouldn't have given it a try!

Funding

Funding is the most serious problem confronting most state natural areas programs, and Colorado is no exception. With a maximum of $30,000 state funds per year and an allottment of only two full time equivalents, how much can be accomplished when the state program is confronted with the following problems created by this lack of adequate state funding?

1. An inordinate amount of time is spent by the one partially state-funded employee justifying continued state funding and raising funds from non-state sources. Time spent raising or retaining funds, a particularly difficult and time consuming task now, is time away from a program already seriously understaffed.
2. Federal funds once available to the Colorado Natural Areas Program (U.S. Fish and Wildlife Service, Office of Surface Mining, Land and Water Conservation Funds, Bureau of Land Management, and U.S. Forest Service) have been eliminated or substantially reduced during the Reagan administration.
3. While federal agencies may grant funds to state natural areas programs to perform field research to gather data on the public lands they manage, they no longer fund land protection efforts. With funding available primarily from federal sources, state programs may become products of what the federal agencies want, rather than the program anticipated by state legislation.
4. Getting additional state funds appropriated is difficult too. This year the State of Colorado is facing a $102-million deficit, illegal according to the State Constitution. Currently, a negative supplemental bill is in the State Legislature to

cut about $50-million from state programs to assist in making up the state deficit, including a 20 percent cut of the $30,000 state funds for the Natural Areas Program.

Coordination With Other Agencies

Federal Agencies

As a state agency concerned with the statewide identification and protection of natural areas, regardless of ownership, coordination of natural area activities on the State's publicly managed lands is a primary function of the Colorado Natural Areas Program. The program has coordinated its activities and policies closely with the following federal land managing agencies in Colorado: Bureau of Land Management (primary contact is the Director of the State Bureau of Land Management's Natural History Management Program); U.S. Forest Service (primary contact is the Regional Director of the Division of Range and Wildlife); and U.S. Fish and Wildlife Service (primary contact is the Chief Botanist, Regional Endangered Species Office).

Memoranda of Understanding exist between the Colorado Natural Areas Program, Colorado Department of Natural Resources, and the Bureau of Land Management and the U.S. Forest Service. These memoranda describe a mutually agreeable procedure for the identification, registry and designation of qualified State Natural Areas occuring on these federally managed lands in Colorado (Pustmueller 1982). The State's registry and designation of State Natural Areas and similar federal designations of Research Natural Areas, Areas of Critical Environmental Concern, Special Interest Areas, and Outstanding Natural Areas, are defined and compared. Fifty-nine percent of the program's 40 registered and designated natural areas in Colorado have been identified and protected in accordance with the memoranda.

Many of these natural areas provide habitat for threatened, endangered or other rare species of plants of national or state concern. They were identified and protected as State Natural Areas under a cooperative agreement for plant conservation between the Colorado Natural Areas Program, Department of Natural Resources, and the U.S. Fish and Wildlife Service, Department of Interior, pursuant to Section 6 of the federal Endangered Species Act. Since approximately 90 percent of the plant species of special biological concern identified by the program occur on Colorado's western slope, many of these rare species are found on federal lands.

Although the State has made headway with the federal land managing agencies in Colorado, there are some problems associated with these relationships. For example:

1. The time lag involved in working with the federal agencies is substantially longer than with state, local, or private agencies or individuals. There are often lengthy public review procedures; withdrawal procedures which must await action at the national level; environmental assessments and impact statements which must be written, reviewed and revised; and multiple-use management alternatives which must be analyzed.
2. Since much of the public land in Colorado and the West has not been inventoried

adequately for potential natural areas, federal agencies must be encouraged to be responsible for what is unknown as well as for what is known to occur on these public lands. The program encourages these agencies (a) to perform field inventories on the public lands to identify natural features on the site which may be of national or state significance and which may need special management, and (b) to incorporate an awareness of 'sensitive species' and 'quality ecosystems' into their land use planning policies and decisions.

3. Since federal agencies are required by the federal Endangered Species Act to pay special attention in the planning process to federally listed endangered and threatened species, coordinating activities on such species is an accepted procedure between state and federal agencies. However, there is no such federal law for species of state concern, unlisted species of national concern, or for rare or quality native plant communities, ecosystems, and geologic features. When such natural areas occur on federal lands in the State, the existing federal laws describing Research Natural Areas, Areas of Critical Environmental Concern, and Special Interest Areas, as well as the memoranda between our agencies, aid in developing and maintaining the federal cooperation necessary to protect them.
4. Under the current administration, the process for listing qualified species by the U.S. Fish and Wildlife Service has slowed down considerably, especially for plants. Unfortunately, federal emphasis is being placed on implementing recovery plans for species already listed as threatened or endangered. In addition to having only five species of federally listed plants in Colorado, there are many species not yet listed which are qualified for listing. Listing often affords protection to a species after it is too late (e.g., not sufficient numbers of populations in a species or of individuals in a population to make recovery efforts through habitat identification and protection effective). Federal funding to the states for protecting natural areas for these unlisted species could help them before it is too late.
5. While the federal agencies are primarily concerned with federally listed species of plants and animals, state natural areas programs generally focus on systems as well as on species, and on unlisted rare species as well as on federally listed species (see definition of natural area given earlier under "State Legislation").

Private Agencies

Many state natural areas programs have developed an inventory of their state's natural diversity to identify scientifically qualified natural areas. Inventories have been developed for some states by the Nature Conservancy under contract with the state. In Colorado, the initial plan was to incorporate the Conservancy staff on the inventory into the state program after the first three years; however, the lack of state funds and state staff positions has made it necessary for the Conservancy to continue to manage the inventory for the program under contract with the department.

Although the database is substantial and provides important information for the identification of potential natural areas for protection by the Colorado Natural Areas Program and for acquisition by such organizations as the Conservancy, the complexity of the public-private arrangement has created some problems:

1. The Conservancy's employees working on the inventory desire autonomy and independence from the Colorado Natural Areas Program, when in fact, the inventory is a part of the Colorado Natural Areas Program and the staff are private consultants to the State. Conservancy staff on the inventory work in state offices to utilize the state property housing the data base. Furthermore, although the data in the inventory are the property of the State of Colorado, the automated database is operated on a non-state computer system by the Conservancy.
2. Like the federal agencies, the Nature Conservancy focuses on the identification and protection of rare species and plant communities, causing inadequate site identification for quality ecosystems and geologic features.

Conclusions

Regardless of these problems, no doubt inherent in varying degrees in all state natural areas programs, the mere existence of these programs provides opportunities for success in the identification and protection of qualified State Natural Areas. The successes of the Colorado Natural Areas Program attest to the fact that much can be accomplished in the present framework, even with the various unavoidable problems. Colorado has registered or designated 40 natural areas, totalling over 60,000 acres (24,300 ha).

The best course of action is to continue as we have been: to identify, evaluate, and protect sites as quickly as possible; to acquire additional knowledge when possible; and to coordinate natural area efforts with other public and private agencies. State natural areas programs must continue to exist to give deserving identification and protection to rare and quality natural features of state and national significance.

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Successes and Problems in Trying to Preserve Natural Diversity

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This paper will present the perspectives of my employer, The Nature Conservancy, whose mission is the preservation of natural ecological diversity. For us this has come to mean the preservation of viable examples, in adequate numbers, of all the species and ecological relationships present in the United States. Our burgeoning international program may soon expand the scope of our mission.

We seek to protect habitats for those species and examples of ecosystems, that, according to scientific data, are not protected adequately in preserves. We operate mainly by acquiring or controlling real estate, and also by attempting to persuade landowners to protect voluntarily the habitats and systems that occur on their property. The Nature Conservancy has sometimes been called "the real estate arm of the conservation movement."

How the Conservancy's Effort is Organized

The Nature Conservancy thinks of its efforts in terms of *identifying* the species and systems that require protection, of *protecting* their best examples through real estate transactions and voluntary agreements, of *managing* those lands where it is appropriate for us to do so, and of fundraising for this enormous effort.

The Conservancy works on a state-by-state basis. We have established staffed offices with strong chapter support in most states. Our effort to identify sites for conservation work is also organized on a state-by-state basis, mainly through State Natural Heritage Programs (Heritage programs) There are now 28 Heritage Programs, the oldest of which was established in 1974. All of these programs were begun by the Conservancy; about half of them are now housed within an agency of a state government.

The Heritage programs manage information on the numbers, location, and status of endangerment of a state's most endangered species and natural community types. The Nature Conservancy attempts to protect both endangered species and natural communities. Our belief is that by capturing good examples of natural community types we can capture simultaneously examples of most species, since most species belong to natural communities. By protecting an oak-hickory forest we are protecting red-eyed vireos and may apples.

However, we also attempt to protect endangered species, since some species have been dislodged from their original natural communities and others are too rare to be found in every example of their habitat. We integrate community and species perspectives as much as possible in our conservation work. Not every bottomland hardwood forest contains a nesting population of Swainson's warbler, since the bird has become pretty rare. Thus, when we are comparing the attractiveness of various forest sites, we might consider the presence of this rare species among the several values that help us decide which forest to protect.

Our protection strategies are quite diverse and, I think, innovative. We have been quite successful in parlaying a thorough knowledge of the U.S. tax code into donations of land. Historically, we have been able to acquire an average acre of land for about half its fair market value. We acquire conservation easements, leases and management agreements, and many kinds of partial interests in property. We have persuaded hundreds of owners to protect their property voluntarily. The Conservancy works with managers of federal lands, helping them identify and designate ecologically significant areas through existing adminstrative processes, such as the Federal Research Natural Area program.

The Conservancy has developed expertise in managing various types of ecosystems, most notably the grasslands of the plains states. Many of our larger preserves are staffed. We are most willing to manage properties that require stewardship expertise unavailable elsewhere.

Successes

In many respects, The Nature Conservancy has been amazingly successful. Since the completion of our first preserve, the Miannus River Gorge in New York in 1953, we have helped protect about 1,700 nature preserves, encompassing nearly 2-million acres (810,000 ha). We continue to own all or in part about 700 of these places. The fair market value for all the tracts the Conservancy has helped to save has been estimated at three-quarters of a billion dollars. The Nature Conservancy has developed the largest system of private preserves in the world.

Eighty plant species and 56 animal species proposed as endangered or threatened in the 1980 Federal Register are found on Conservancy preserves, many of them on several preserves. The Conservancy controls 13 barrier islands and thousands of acres containing many of the major ecosystem types in the United States. We have a large staff of capable land stewards. In the last three years alone, the Conservancy has generated more than $10 million in cash and millions more in land from corporations and corporate foundations. In 1982, the Conservancy raised $19 million from foundations alone.

Problems in Achieving Our Goals

Although The Nature Conservancy's work has provided relief for many species and communities under seige, several roadblocks keep us from complete success. I'll discuss these under our four major program divisions: identification, protection, stewardship, and fundraising.

1. *Identification.* The landscape keeps changing. In a way we're persuing a moving target. As land is bought and sold, plowed, ditched, drained, and grazed, it is hard to know everything that is happening out there. Between 1967 and 1975 almost 14 percent of the non-federal land in this country—about 219-million acres (88.7-million ha)—was converted from one use to another. It is hard for any data system to keep track of the status of the thousands of areas we feel we need to monitor.

Furthermore, many remote areas of the United States have not been surveyed for rare species or communities. It is hard to make conclusive statements about the status of endangered plant species in the Nebraska Sandhills or the Great

Basin, for example. We often find ourselves operating on the best information available, and hoping that is good enough.

2. *Protection*. There are many limits to the abilities of private conservation organizations to protect every significant acre. For one thing, about 40 percent of all land in the United States is owned by public agencies. Much of this land is grazed, timbered, mined, farmed, or played upon. Very little of it is managed to protect elements of natural diversity.

Also, many private owners will not sell or donate their property. Owners see their properties in different ways, sometimes with a fierce emotional attachment. Some see property as a link to the past, others as a bridge to the future. Property owners want their land to be all sorts of things—a place to live, to work, a source of income now or someday, a source of continuity, food, security, investment income, serenity, beauty, or tax relief. Private conservationists are not always able to cut a deal. And of course, having to raise money is a challenge to all conservation groups, public or private.

3. *Land Stewardship*. Our biggest problem here is eternity. In a world as precarious as ours, it sometimes seems absurd to think about protecting all these places forever. Various forces gnaw away at the borders of the Conservancy's nature preserves already, and we've only been around since 1953.

General environmental forces, largely beyond our control, threaten natural areas in many ways. Acid rain, the depletion of aquifers, and air and water pollution, are among the most troublesome. As water becomes more scarce, natural area conservationists will have to become much more sophisticated and determined. And of course, the money to burn prairies, fence areas, build boardwalks, and pay staff is always on a steward's mind.

4. *Fundraising*. Having reported earlier that The Nature Conservancy is a successful fundraising organization, it is also necessary to say that the competition for charitable donations seems to become more fierce by the day, particularly when the private sector has been asked by the current administration to provide some of what the public sector has provided in recent years. Raising money is hard work.

Summary and Prognosis

So it's a mixed bag. Private conservation groups, including The Nature Conservancy, can point to decades of real accomplishment. There are many important preserves out there. Our ability to select which species and communities require attention seems to get better all the time. Enhanced computer technology will sharpen this focus rapidly. There is a good basis for predicting progress in our ability to manage endangered species in the near future. There is certainly considerable support for natural diversity protection among the citizens of the United States. State governments, too, despite the current punishing economic climate are enacting easement laws, non-game check-off programs, and other natural area legislation at a heartening rate.

Missing, however, is a national commitment to the preservation of natural diversity. If only that small fraction of landscape which contains the significant remainder of our natural heritage could be protected through a strong federal commitment, much of the burden on the private sector would be eased. There is ample precedent in other nations of the world.

Many of America's native ecosystems and many of their constituent species have been broken or buried in the stampede of civilization. The intrinsic importance of these populations and systems, and their importance to human welfare and survival, are not adequately recognized in public policy. The private sector can accomplish a lot, but not everything. This is something for everyone to work for.

Implementing the RNA Program in the Intermountain Region, USDA Forest Service

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Introduction

I have been asked to share some observations on my experience with the RNA program. Shortly after arriving in the Intermountain West—with no prior involvement with RNA's—I found myself to be chairman of the Forest Service Intermountain RNA Committee. The Committee represents the Regional Forester of the Intermountain Region and the Director of the Intermountain Forest and Range Experiment Station.

The Committee serves to determine needs for research natural areas; to assist in preparing establishment reports; and to provide oversight to the process of locating and establishing RNA's on 18 National Forests with over 31 million acres (12.5-million ha) of National Forest land in Utah, Nevada, southern Idaho, and western Wyoming.

Observations

I found that substantial progress had been made. We have had 18 established RNA's of from 40 to 5,550 acres (16 to 2,248 ha), and totaling 28,300 acres (11,462 ha). Many new candidate areas are being analyzed.

Citizen Involvement

Interest and involvement of individual citizens, volunteers, and conservation organizations have been prime factors in making things happen in our region. I speculate that few of our 18 areas would have been established without this help.

In 1974, the Idaho Natural Areas Coordinating Committee (INACC) organized and ran a workshop on natural area needs in Idaho. It involved about 50 people of various backgrounds, skills, and interests. The report, published by the College of Forestry, Wildlife and Range Sciences at the University of Idaho, was "A First Estimate" of RNA Needs. In 1980, based on six years' field experience, the INACC revised its needs list. The Forest Service adopted the INACC list as the basis for its RNA program.

We had no similar comprehensive needs list for Utah and Nevada until The Nature Conservancy (TNC) began to give increased attention to public lands in the West. In 1982, TNC organized and conducted a RNA workshop involving over 70 people from various locations, organizations, and disciplines. They have published a first estimate of RNA needs for these two States. This will be a tremendous help to the Forest Service as well as other agencies.

The INACC and TNC also have contributed greatly to the fieldwork necessary to search out, explore, screen, and recommend new RNA's, and to prepare establishment reports. Individual volunteers, members of these two organizations or recruited by them, have donated many weeks of personal time and effort to fieldwork and report writing. The Forest Service and, in some cases, TNC have paid travel costs for the volunteers. Through these conservation organizations and volunteers, the agency has gotten a lot of valuable work done for very modest amounts of money.

Forest Planning

The advent of forest planning required by the National Forest Management Act (NFMA) seems to be having a mixed effect on the RNA effort. NFMA regulations require consideration of RNA candidate areas in each Forest plan. RNA's may be valuable baseline areas for monitoring and assessing the effects of management activities and systems as required by NFMA. Thus, more people than ever in the Forest Service are aware of and interested in the RNA program. At the same time, the pressure of meeting deadlines, the complexity of the planning process, and the huge workload have tended to result in some interim delays in getting new RNA's actually established. Another problem is that each forest tends to handle RNA's differently in the planning process. There also are differences among forests in their attitudes toward treatment of RNA proposals. Establishment is to come about *through* forest planning, and it is taking a while to get the new process established. The net effect, once the dust has settled, probably will be positive.

Classification Systems

On a national basis, RNA's are classified according to Kuchler vegetation types and Society of American Foresters' (SAF) forest types. Although this is necessary for purposes of a national program, it is not useful in the West. Our needs lists, field searches, and establishment reports are based on habitat types.

Much work has been done to classify forest ecosystems and some nonforest ecosystems (vegetation and sites) according to potential climax vegetation. This work has been built on the concepts and methods developed by Rexford Daubenmire, first published in 1952. Practical experience by field foresters and rangeland managers has shown that the habitat type is a meaningful and useful basis for planning and managing ecosystem resources.

In the West, great variations in geomorphic character, soil parent materials, topography, elevation, precipitation, aspect, and other environmental factors result in great variations within the broad concept of SAF forest type or Kuchler vegetation type. For example, research and development work in forests of Montana, central Idaho, eastern Idaho-western Wyoming, and southeastern Idaho has identified the following:

SAF Type	Montana	Central Idaho	Eastern Idaho-Western Wyoming	Southwestern Idaho
	Habitat Types	Habitat Types	Habitat Types	Community Types
210 Interior Douglas-fir	15	17	14	—
237 Interior ponderosa pine	5	7	—	—
217 Aspen	—	—	—	23
205 and 206 Subalpine fir	25	23	35	—
213 Grand fir	3	9	—	—
218 Lodgepole pine	12	26	—	—
208 Whitebark pine	—	—	5	—
219 Limber pine	—	—	4	—

In Idaho, Oregon, Washington, Montana, and Wyoming, the big sagebrush (*artemisia tridentata*) rangelands include at least 23 separate habitat types.

This use of the habitat type concept in our RNA work provides us with a sound scientific base and makes the RNA's more useful as potential baseline areas. It also makes our work complex and indicates the need for a large number of areas in the national network. For example, although the 10 RNA's established in National Forests in southern Idaho include many cells (habitat types; rare, endangered species; aquatic situations; etc.), our revised needs list shows about 30 cells to be searched for in each of these seven Forests.

Finding Suitable Areas

One of our challenges in the Intermountain Region is locating areas suitable for designation. The Forest Service Manual states, "As a general guide, these areas should show no evidence of major disturbances by man, such as livestock grazing or timber cutting, for at least the past 50 years. On occasion, however, in a valuable plant community that should be preserved, the most suitable area that approaches these conditions should be selected."

Although much of the West is sparsely settled, the relatively few people who have been there the past 150 years have made lots of tracks and left lots of evidence. It is hard to find areas that have not been impacted and altered by livestock grazing especially, but also by mineral exploration, logging, recreation, irrigation projects, and homesteading.

Finding Available Areas

Another challenge is finding areas that are available for RNA's. For some habitat types, such as those at high elevations or in remote locations, it is easy because there are few demands or alternative uses. In other cases, it is difficult because of needs and pressures for grazing or timber production. Sometimes there are conflicts with recreation and minerals uses. To be complete and to serve baseline monitoring purposes, the national RNA network should include some very productive habitat types. This will require some sacrifice of economic uses, and this is difficult for public resource stewards to achieve.

Baseline Data

One of the problems that has come to my attention is the lack of baseline data on RNA's. Relatively little effort has gone into collecting and analyzing baseline data. Most of our energies are being used to locate and establish new RNA's. Obtaining baseline data is a challenge that lies ahead of us.

Funding

Thanks to the help of dedicated individual volunteers and conservation organizations, we have accomplished considerable work with modest amounts of money taken "off the top" of Station and Region budgets. Under the present system, RNA work is not provided for as a distinct activity in work planning and budgeting. It generally is handled as an extra duty by employees and funded on an *ad hoc* basis. We have recommended to National Headquarters that they consider making the RNA program a regular part of the work planning and budgeting process. It remains to be seen whether this will be done and, if so, whether it will help accelerate work on RNA matters.

Conclusion

My short experience with the RNA program in the Intermountain Region has been instructive. I have become convinced that conservation organizations and dedicated individual volunteers have been absolutely essential to our progress so far. I see them as essential to future accomplishments—even if the agency decides to increase its emphasis, work plans, and budgets for RNA's.

Forest planning under NFMA has given us some difficulties in the short run. Meshing the ongoing RNA establishment effort with the new and evolving planning system has been challenging, and may have delayed some establishment. However, the net effect will be positive as more of our employees become aware and involved and as the forest plans include RNA considerations.

I am impressed with the habitat type approach to ecological classification and its acceptance and use by resource managers. It gives our RNA's a strong scientific base.

Our problems in finding ecologically suitable areas that also are available, obtaining baseline data, and getting strong funding are, I am sure, common to other regions and organizations.

A National Perspective on Natural Area Programs: Major Problems and Suggested Solutions

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Introduction

I wish to thank our Chairman, Mr. Grimmett, for inviting me to participate in this Special Session on Natural Areas, and for allowing me to deviate somewhat from the planned program.

The purpose of this paper is to provide some broad national perspective on the basic situation in which natural area selection and management efforts currently operate, and on how they might better operate in the future. First, I will highlight a few of the many fundamental problems that presently limit the effectiveness of natural area programs throughout the United States. Then, I will propose some ideas for nationwide institutional and operational improvements which I think could greatly contribute to rectifying these systemic problems.

I want to emphasize that I am presenting my own views and ideas resulting from my professional knowledge and experience. This paper does not necessarily represent the views or preferences of any organizations with which I am affiliated. My hope in presenting these thoughts is that they will help focus discussions and perhaps stimulate further constructive actions.

The Accelerating Loss of Natural Diversity

Over the past 20 years or so, substantial evidence has been compiled which demonstrates that the often impulsive, land- and energy-intensive activities of our continually expanding human population are reducing the amount of unaltered, natural land and water at a steadily increasing rate. The evidence also shows that along with this quantitative loss there has been the more significant qualitative loss or near loss of whole units of natural diversity. For most kinds of land development, it would be physically possible, over time, to return individual sites to some types of vegetated, "naturalistic" conditions. But, when the last specimen of any particular type of natural diversity element is altered or eliminated, that whole unique element and all its resource potentials are irreversibly lost—forever.

Of all of these losses, the best known is the rapid growth in the extinction rate of irreplaceable plant and animal species that has been well documented by numerous authorities. As most of us here today know, the number of recent extinctions and the great potential for many more in the near future have been recognized as such significant global problems that many governments and private entities throughout the world have organized various programs in attempts to deal with them. All these efforts are guided by what may unfortunately prove to be only desperate hopes of slowing the extinction rate, either by preserving the last few members of the rarest species as long as possible, or by preserving as many members of as many threatened species as possible until the programs' limited resources run out.

Whether regarded as "improvements" of otherwise "nonproductive" lands, or as "destruction" of otherwise "invaluable" resources, there certainly can be no argument that most land uses and land management actions reduce or eliminate the natural quality of the natural phenomena they affect. The cumulative effect of all these actions is to decrease the distribution and abundance of many whole categories of natural diversity. If allowed to proceed without being balanced by deliberate, rational selection of protected areas comprising an in-place Noah's Ark that exemplifies all remaining elements of natural diversity (defined at an effective and manageable level), these disruptive activities will eventually leave only random, widely separated and incomplete patches of fair to poor naturalness. Such patches will then represent only a few of the many natural diversity elements existing today.

In many regions of the United States, of course, we have already created this condition through extensive conversion of the natural landscapes that existed just 200 years ago. This fact leads to serious questions regarding the capabilities of many of the remaining patches of biotic diversity to maintain their natural composition, properties, and processes, even if they are protected from any further human disturbance. However, for years, many people deeply concerned about the long-term welfare of future human generations have persuasively argued that losses of the remaining natural diversity elements will inhibit many practical improvements, and probably the maintenance, of current levels of the quality of life. More than that, it is easy to foresee the real possibility that such losses could eventually make survival of the human species itself much more doubtful than it appears to be today.

Over the years, many eloquent arguments have been expressed against allowing these projected possibilities to come about. The most persuasive of these is the economic and evolutionary principle of flexibility provided by having maximally diverse raw resources that can someday be used as substitutes for other expired or less effective resources, or that may be discovered to have properties which satisfy current or unanticipated future needs for which no other solutions will ever be identified. Another primary argument is the value of the scientific information that may someday be derived from studying high quality examples of each type of natural phenomena. By improving our understanding of many different natural systems and processes, such information is invaluable for predicting future natural events, for identifying economically valuable resources, for judging the effects of land uses occurring elsewhere, and for improving the management and execution of those land uses.

Providing opportunities to fulfill these very basic resource management needs is one of the paramount purposes of many public and private natural area protection programs. But it has only been in recent years that a number of natural area programs have been aimed specifically toward protecting unique or representative samples of a broad range of discrete categories of natural diversity. Therefore, many remaining natural diversity elements still do not have any examples sufficiently well protected to ensure the long-term maintenance of the natural qualities that are needed for those values to be fulfilled, or even to ensure the continued existence of the elements in any condition. Furthermore, many lands already receiving significant protection investments may not actually contain the most natural, most viable, most typical, or most unique examples of the natural diversity elements represented. While there may be many other good reasons for protecting those areas, the risk that the last (or otherwise most valuable) examples of many diversity elements will soon be altered or eliminated continues to run very high, due to ignorance of their importance or lack of adequate protection.

Basic Communications and Logistical Problems

Simply arriving at a mutual understanding among interested parties as to the meaning of the term "natural diversity" is a difficult communications problem unto itself. The term is so vague, and can be logically defined on so many different hierarchical levels, that without a specific definition it either communicates nothing substantive or is subject to many interpretations. "Natural diversity" generally means the number of different *types* of natural phenomena (defined at some specific level) that have at least one example within the referenced geographic area. The most manageable solution to this problem instituted thus far is The Nature Conservancy's (TNC's) concept of "natural diversity elements," which is defined as consisting of all the types of remaining natural terrestrial and aquatic communities, "special species," and "geologic features," where each of these types is specifically classified on a state-by-state basis. This concept accounts for two crucial levels of biotic diversity (species and communities); but it is limited by its failure to recognize higher levels of natural biogeographic differentiation, which account for basic differences among examples of individual community types and among populations of individual species. It is also limited by its lack of comparable distinctions among geophysical categories.

As uniquely defined categories of organisms possessing certain common characteristics, species are usually identifiable and often quantifiable units of biotic diversity. But, each type of biotic community is a diversity measure that is more readily identifiable and quantifiable than many species, because it is larger and basically consists of a unique blend of plant and animal species whose populations repeatedly occur in close spatial proximity to each other. Each community type is also uniquely characterized by the dynamic relationships among populations of its constituent species which they do not exhibit in isolation. Thus, the total community diversity (i.e., the total number of community types) occurring in a given territory encompasses that area's total species diversity, provides some additional dimensions of biotic diversity, and is much easier to count.

Even with these advantages and with the remaining limitations of TNC's definition overlooked, there are many other factors that presently interact to create enormous challenges for natural area programs focused on natural diversity preservation. The primary factors include:

—The very large number of natural diversity elements still represented by one or more remaining examples that need to be identified, inventoried, and evaluated for protective management selections;

—The wide range of deviations from "pure" natural conditions that exists among the (often numerous) examples of remaining elements which need to be comparatively evaluated;

—The evolutionarily and geologically rapid rates at which natural and viable examples of so many elements are diminishing and whole elements are disappearing;

—The number, variety, intensities, and (often complex) interactions, among the natural and anthropogenic forces causing those declines;
—The many gaps and imperfections in our current knowledge about each of the above factors;
—The desire of many people to preserve at least the "best" (and often more) remaining examples of as many elements as possible; and
—The severely limited human resources currently available to fulfill that desire.

As if these challenges were not enough, the programs are currently hamstrung by many organizational and operational problems that consume their energies and seriously limit their efficiency and effectiveness. The following discussions will attempt to highlight some of these central problems.

Insufficient National Leadership on Behalf of Natural Diversity Protection

In response to increasing public demands over the past 100 years, many Congresses and Presidents have asserted national leadership by initiating, supporting and encouraging Federal, State, local, and private efforts to fulfill environmental protection needs of various kinds. Some of these efforts, such as National and State Park, Wildlife Refuge, Wilderness, Wild and Scenic River, and Endangered Species Programs clearly offer important degrees of protection for some examples of many different natural diversity elements. The National Environmental Policy Act, the National Forest Management Act, and the Wilderness Act even contain some general provisions pertaining to the representation or maintenance of diversity. However, many diversity elements are still unprotected, and no Congress or Administration has yet asserted the kind of leadership that will effectively direct adequate national attention toward managing the best example of each natural diversity element to ensure its best ultimate use. Even the several attempts at passing natural diversity or natural heritage protection legislation that have been made over the past 10 years all failed because of fundamental weaknesses in their conceptual approaches and/or their political strategies.

Until the importance of maintaining the nation's complete range of natural diversity is formally recognized, and until strong, sustained and thoughtful leadership toward this goal is clearly provided at the national level, the various Federal, State, local, and private natural area programs that attempt to address diversity must continually divert inordinate amounts of their resources to obtaining each year's rather small funds, while more prominent programs that readily receive budgets fail to contribute nearly as much as they could to natural diversity protection. Furthermore, without that leadership, efforts to solve most of the hindering problems described below will be minimally effective, allowing them to continue draining the limited resources of both public and private natural area programs and seriously restricting their chances for significant success.

Fragmented Programs

Natural diversity preservation efforts are greatly hampered by the highly complex institutional fragmentation that is well entrenched in our society. Highly fragmented land ownership and jurisdictional patterns that respect almost no natural boundaries, of course, inhibit all types of resource management. Ownership and jurisdictional divisions might be more workable if they happened to be aligned with patterns of natural phenomena. However, the current three-dimensional, geometric jigsaw puzzle of legal rights and administrative responsibilities among many different government levels and units, and private parties, leads to conflicts, delays, and incomplete actions where natural resources are artifically divided among owners who often have conflicting objectives.

Another complicating factor is the multitude of specific legal authorities and operational capabilities needed for effective natural area selection and management that are randomly split among so many public and private institutions. No one entity at any level has a full complement of the powers, information, expertise, manpower, and facilities needed to effectively select, manage and ensure beneficial use of the best examples of all natural diversity elements, even for its own lands. Furthermore, many notable Federal and State land- and natural-resource-managing agencies do not yet have any programs that are effectively aimed toward the goal of preserving the best examples of natural diversity within their jurisdictions.

A related problem is the fact that the many members of the "conservation movement" are only unified by vague, unquantifiable goals. The term is really just a general label for a number of fractionalized, often competitive interests, most of which are narrowly focused. Each interest concentrates on protecting one or a few particular examples or elements of total diversity that it judges to be of some special value, or on promoting one or a few specific types of conservation values or legal protection measures, without giving substantive attention to representing the full range of diversity. Thus, there is still no organized, visible constituency working on behalf of all diversity elements. Even TNC, which is the only national organization thus far to initiate meaningful efforts to protect a broad array of natural diversity through a variety of means, has yet to devote much attention to geophysical elements.

The result of all this fragmentation is that many elements, and certainly many excellent examples, of natural diversity are arbitrarily ignored by conservation efforts, leaving their fates largely to chance. Meanwhile, investments are concentrated, often unwittingly, on protecting duplicate or lower quality examples, or just a limited range, of other elements. This means there is a high risk of many very valuable natural areas being lost, perhaps without anyone even knowing what their full values might be.

Inadequate Interinstitutional Cooperation

With the fragmentation described above well established and not likely to change much in the foreseeable future, those few Federal, State and private natural area programs which do have goals of protecting valuable examples of natural diversity that occur within their jurisdictions are highly dependent on each other and on many other programs in their own and in other agencies for much of the information and action required to meet those goals, especially if they are to avoid wasteful duplication. This makes effective communication and cooperation between the respective programs absolutely essential for significant accomplishments. But, even within a single state, the number of different organizations with which a given natural area program needs to communicate places an extreme burden on that program's staff and consumes much of its time. Each lapse in such communications carries risks: of losing valuable opportunities for protective action, while those of lesser value are pursued; of mismatches between cognizant organizations' legal, professional, and financial capabilities and the needs of particular situations; and of inefficient duplications.

A few arrangements for deliberate interinstitutional coordination and cooperation in natural area selection and management do exist and some others are currently being developed, but there are far too few of them and each one has significant limitations.

At the national level, the Federal Committee on Ecological Reserves (FCER) was organized in 1974 to coordinate the selection and management of Research Natural Areas (RNA's) and "Experimental Ecological Areas" on those Federal lands best representing the full array of natural diversity and intended primarily for observational and manipulative scientific research, respectively. Developed under the joint leadership of the President's Council on Environmental Quality and the National Science Foundation (NSF), the FCER's charter identifies 19 Federal land- and resource-managing agencies as voluntary members. In addition, representatives from 10 national academic, professional and conservation organizations have, in the past, attended meetings as observers and assisted the Committee in various ways. However, these organizations are not actually members, and no State Government representatives are included. More importantly, no official Legislative or Executive mandate establishing the Committee's mission and membership exists, and none of the Federal agencies has made any formal commitment to participate in it. Therefore, the FCER's efforts have mostly been at the staff level, rarely (if ever) involving the agencies' upper managers; and it has no decision-making authority. Furthermore, the Committee has not met since December, 1979, making it effectively inactive, although its charter still stands and most of its member agencies continue to operate their respective programs.

Another voluntary, national-level, interinstitutional group which *does* meet fairly regularly is the Directorate of the U.S. Man and the Biosphere Program's Biosphere Reserve Project (MAB-8). The whole MAB Program is designed to be interdisciplinary and interinstitutional, so the MAB-8 Directorate does include members from four universities, a research institute, TNC, the Society of American Foresters, and seven Federal agencies, but none from State governments. Not only does that Directorate (like the FCER) not have any authority over its members' natural area programs, it currently does not even serve to exchange information or coordinate those programs. Instead, the MAB-8 Directorate's primary function is to coordinate the nomination of already protected areas representing the primary components of each of the country's biogeographic provinces, for designation as Biosphere Reserves. It also monitors the management and use of the 38 currently designated Biosphere Reserves in the United States, and reports on these activities to the U.S. National Committee for MAB. The Biosphere Reserve Project's basic scope of concern is the conservation of natural areas and the genetic material they contain, which indicates that it strongly emphasizes biotic elements over geophysical, although the latter do receive some attention.

To my knowledge, only three formal agreements exist among Federal agencies at the national level regarding any natural area programs. These are the Memoranda of Agreement that the National Park Service (NPS) Director has signed individually with the heads of the U.S. Forest Service (USFS), Fish and Wildlife Service (FWS) and Bureau of Land Management (BLM). They pertain only to the conduct of NPS' National Natural Landmarks (NNL) Program on lands administered by those agencies. These agreements do not provide for coordination of any other natural area programs of those agencies with the NNL Program or with any other NPS Program, and they do not establish a regular coordination process. They only express the agencies' general intentions to respond to NPS' requests for information and proposals for NNL nominations, without necessarily committing any land or substantial human resources to the Program.

At the State level, I am aware of only one multi-agency committee that has already been formally established by written agreement to coordinate the selection and management of a natural area system representing a state's complete spectrum of natural diversity. That is the Alaska Ecological Reserves Council (AERC), whose official members include the State or Regional heads of six of the major Federal resource management agencies, heads of three State resource management agencies, the University of Alaska's Vice-President for research, and the President of the Alaska Federation of Natives. The Council's primary purpose is to coordinate selection, management, baseline monitoring, and educational use of Research Natural Areas, Experimental Forests, and similarly designated areas among the member agencies. Unfortunately, no private conservation organizations are members of AERC. Also, only a few of the member agencies actively participate in these efforts at present, and they are hampered by the lack of a computerized natural diversity data management system to handle their enormous information needs.

One other formal committee is now on the verge of being established in California, through development of an agreement among the directors of California's Fish and Game and Parks and Recreation departments; the State/Regional heads of BLM, USFS, NPS and FWS; and TNC's State Director. Under the current plans, the Committee will not include any academic members (even though the University of California owns and operates a sizable system of land and water reserves) and will not be intended to coordinate research use of natural areas. But it is intended to coordinate member agencies' natural area programs through a cooperative process that systematically identifies, evaluates, selects, and manages California's most valuable examples of natural diversity. This process will rely heavily on the services of Fish and Game's California Natural Diversity Data Base.

Oregon and Washington are both covered by one very active, but still informal, RNA Committee composed of several Federal agencies. Through that Committee, the Federal agencies have adopted the element needs and priorities established by both State Governments in their respective Natural Heritage Plans. This action provides mutually ranked element targets for inventory, site selection, and ultimate additions to the Federal RNA system and to the complementary State systems. Representatives from both State Heritage Programs and TNC regularly attend Committee meetings, but only as observers. Also, a number of the Federal agencies do not actively contribute to the Committee's efforts. The agencies that are most actively involved are USFS and BLM.

It is the Federal representatives who are the observers at the informal Idaho Natural Areas Coordinating Committee, which selects and recommends sites it feels should be established as RNA's by their respective owners or administrators. In contrast to the Idaho Committee, which operates outside the resource management agencies and without the benefit of a State Natural Heritage Inventory

Program, Tennessee's committee does involve representatives from three Federal and two State agencies, including the Heritage Program Director, as well as TNC. But it also is an informal arrangement.

In addition to the above limitations, only the California Committee is planned to directly involve the respective agency heads through an executive steering group that will meet at prescribed intervals and play a specific role in the cooperative process.

In some states, formal two-party agreements have been executed by key State and Federal agency heads to establish basic principles and procedures for cooperation between their respective agencies relative to natural diversity data management or natural area selection and management. While these agreements establish some mutual commitments that serve some of the participating agencies immediate purposes very well, they are not nearly as efficient as committees. A committee brings several agency representatives together (not just two) to share information, coordinate operations, and determine each agency's most constructive role in each particular area or project.

Despite the respective drawbacks of these cooperative arrangements, each one is still a vital systemic link between artificially fragmented programs. The greatest problem is that so few of them exist.

Confusing Designations

Another problem that plagues both managers and users of natural areas, and frequently impedes effective protection of them, is the over-abundance of vague and conceptually overlapping natural area management designations. Very few of the interrelationships among these designations are well defined. Most of the existing designations are operationally differentiated primarily by which government level and unit or which private organization is responsible for them. For example, among just seven Federal land- and resource-managing agencies, there are more than 30 different types of administrative designations applicable to various kinds of undeveloped lands. Add to these the numerous titles used by the States, uncountable supra- and sub-state governing bodies, and many national, state, and local conservation groups, then multiply that sum by all the obvious and subtle differences in their definitions and in the rules guiding their establishment and implementation, and you *may* have a measure of the vast maze of confusion that exists.

Some of these designations have been or can be applied to the same sites, sometimes for practical reasons, other times apparently not. Which designations to apply in which situations is often a difficult choice for managers, and many people are often puzzled about what some designations actually mean in terms of management purposes and use restrictions. For many designations, legal import is a gray area that is not often well explained.

Although many types of designations provide at least some protection for some examples of some natural diversity elements, many elements have multiple examples protected under them, while others have none, because balanced representation of diversity is a serious criterion for only a few of the designations. Among the nationwide designations, the ones that do seriously address diversity are Research National Area, National Natural Landmark, Experimental Ecological

Reserve and Biosphere Reserve, but each of these has some significant gaps in its present standards, procedures, and effectiveness. Furthermore, the ways they should relate to each other and to other specific designations have never been clearly delineated by any authority. Each one is now administered independently, adding to the communication burden of many agencies.

The reasons these four designations address natural diversity representation are that each emphasizes the scientific values of natural areas, and scientific research is essential to discovering and making available the many untapped, tangible human benefits that are stored in the most natural, most typical, and most unique examples of diversity. While many other national designations identify scientific values among their general scopes of concern, they also symbolize (in fact, usually emphasize) other land protection values, many of which conflict with natural science when they are simultaneously sought in the same places. Without clear relationships between the other designations and the four scientific ones, it is difficult to identify which areas or subareas under the other designations are to be managed primarily for their natural science values.

Additional Operational Problems

Other significant problems in natural area selection and management include the following:

1. There is little consensus, and few of the site-specific studies needed, among the various responsible agencies and officials, regarding standards for determining:
   a. The minimum number of examples of each natural diversity element that needs to be protected to ensure the element's preservation and fulfill scientific needs; and
   b. The minimum size each example of each element must be to adequately sustain that example's natural properties and processes.
2. There are still a number of States that have not instituted ongoing natural diversity data management programs like those formulated by TNC, and all the existing programs still have major gaps in their data for several basic categories of natural diversity.
3. There are not enough permanent baseline monitoring systems and research data exchange mechanisms for established natural areas to permit the place-to-place, element-to-element, and time-to-time comparisons that fulfill the purpose of representing the full range of natural diversity in a network of sites.
4. There is limited awareness among the scientific community of the protected sites that are available to them for long-term field research.
5. The results of research done in natural areas often are slow in getting to the resource managers who can use them best.

Proposed Solutions

With all these very substantial problems (and many others there is no room to mention here) limiting nationwide selection, management, and use of the most scientifically valuable examples of natural diversity, what then should be done to solve them?

The first principle in forming an effective solution to all these problems is to recognize that preservation of natural diversity is a holistic, unifying goal which can serve to systematically integrate many otherwise disparate conservation efforts toward a common purpose.

However, to be of much value in unifying and guiding so many different organizations toward effective action, the goal must be clearly and pragmatically defined in quantifiable terms; and it must be physically and politically feasible to approach achievement of it within a foreseeable time period. It certainly is not realistic or very persuasive to give the impression that the goal of natural diversity preservation is to protect every remaining acre of "raw" land from development, or even that it is only to protect as many remaining natural or nearly natural areas as possible for all the future opportunities they can provide. It seems much more constructive to ensure first that all of the natural areas of greatest scientific value are managed for ultimate fulfillment of that value, where it is properly judged to dominate all others. This should be done by very selectively protecting and facilitating primarily scientific and educational uses of only the most natural, viable, internally diverse, typical, and unique examples of each natural diversity element, in a comprehensive nationwide network of scientific preserves. If this actually is achieved, at least we will have the most important natural areas protected from loss and managed for their highest and best uses. Additional areas can then be protected if the will and capabilities to do so still exist at that time.

Next, to guide fulfillment of this goal, there needs to be a permanent, formally established, national-level coordinating committee that reports directly to both the President and Congress. It should consist of qualified upper managers and support staffs from at least the major Federal land-managing and environmental-research-performing/funding agencies. It should also include selected State government representatives (perhaps from the National Governor's Association), selected public and private environmental research institutes and universities (especially those operating their own research reserves), key national conservation and professional scientific organizations (at least those which own, manage, or certify natural preserves for scientific purposes), and, eventually, representatives from each of the State/regional-level committees described below.

Focusing on the above goal, this committee should have several critical functions to assert national leadership in scientific preserve selection, management, and use efforts:

1. It should author and oversee implementation of a durable mandate and basic organizational and functional guidelines for a complete nationwide network of parallel State/regional-level research/scientific-preserve/resource-management coordinating committees. These committees would probably be best modelled on a blend of the characteristics of those now operating in a few States, including those mentioned previously, and the Southern Appalachian Research/Resource Management Cooperative.
2. The national committee should revise national standards and procedures (among at least the major Federal land-managing agencies) regarding the selection, management, and use of Research Natural Areas, Experimental Reserves, Hydrologic and Soil Benchmark areas, Experimental Ecological Reserves, National Natural Landmarks, and Biosphere Reserves. It should provide consistent, coordinated guidance to set basic priorities and facilitate cooperative field efforts in these programs; to give the State/Regional committees a common frame of reference; and to guide them in effective integration of, not only all

the Federal agencies' efforts, but State, private, and academic ones, as well as those of organizations not directly participating in the committees. Following the basic models and building upon the systems already provided by TNC's State Natural Heritage Programs, these directives and guidelines should cover such functions as: natural diversity element classification; element priority ranking; element occurrence inventory and analysis; potential site identification and evaluation; site selection and establishment; site management and use; and the distribution and application of research results.

3. Revising the names, roles, and definitions of existing designations to the extent necessary, the national committee should also establish one clear, complete, and coherent national system of natural area designations which:
   a. Will categorically and procedurally distinguish groups of designations applicable: (1) primarily to scientific values and the representation of natural diversity, (2) primarily to recreational and other individual values, and (3) to specific multiple values of equal importance;
   b. Will categorically and procedurally differentiate those designations that actually affect management and use of lands from those that only recognize and operationally or symbolically link sites where protective management commitments have already been made, and also from those that only symbolize scientific findings of significant values by State/regional committees, as inputs to management decisions by other responsible owners or administrators; and
   c. Will define systematically integrated, operationally effective roles for the national scientific reserve designations, in relation to each other and to other national and State natural area designations.

This third effort should be designed to eliminate confusing ambiguities and wasteful overlaps in existing definitions and roles of the designations and to logically define the circumstances in which particular designations may overlap each other on the same sites. The basic intent of the ultimate set of scientific preserve designations should be to symbolize a complete national network of field sites which best represent all elements (and thereby all levels) of natural diversity, and which provide opportunities to perform both manipulative and non-manipulative field research on separate examples of each element.

My specific suggestion for integrating the scientific preserve designations is to define them in a three-tiered hierarchy parallel to a taxonomic hierarchy, where each individual designation covers one whole unit of diversity that is identified within the corresponding taxonomic category. The lowest level designations would each individually cover at least one occurrence of at least one natural diversity element. Each higher level, symbolic designation would then be composed of multiple sites designated at the successively lower levels.

To clarify this idea further, for these purposes all natural diversity should be classified within the following spatial/taxonomic structure:

I. Realm
  A. Province
    1. Region
      a. System
        (1) Class

(a) Element
(i) Occurrence.

Only two realms should be defined: Biotic and Physical (i.e., living and non-living). Within these two realms, the entire country should be classified under the following basic headings:

I. Biotic Realm
  A. Biogeographic Provinces
    1. Biogeographic Regions
      a. Ecosystems
II. Physical Realm
  A. Physiographic Provinces
    1. Physiographic Regions
      a. Physiographic Systems

The provinces should all be delimited and defined by the national committee. The regions, which compose each entire province, and the systems, which compose each entire region, should all be delimited and defined by each respective State/regional committee, which should also have responsibility for defining each of the specific elements expected to have one or more occurrences in each of the defined systems. The classes in which the elements should be defined for each system are:

I. Biotic Element Classes
  A. Terrestrial Plant and Animal Communities
  B. Aquatic Plant and Animal Communities
  C. Cave Communities
  D. Special Plant and Animal Species
    1. Federally listed Threatened and Endangered species
    2. State-listed Threatened and Endangered species
    3. Other sensitive species (as appropriate)
II. Physical Element Classes
  A. Landform Types
  B. Water Body Types
  C. Geologic Materials
    1. Surficial Deposit Types
    2. Rock Types
    3. Fossil Types
  D. Subterranean Structures
    1. Cave Types
    2. Others (as appropriate)
  E. Soil Types

Each State/regional committee should also define what constitutes an occurrence for each element it defines. The number of smaller units distinguished under each respective larger unit should be determined by the character of the environment, not some arbitrary standard. Some provinces may have only one region, some regions only one system, some classes only one element, and, unfortunately, some elements only one occurrence.

The lowest level designations (e.g., Research Natural Area and Experimental Reserve) should be selectively applied to the most scientifically valuable contiguous aggregations of element occurrences and should be established to include at least one occurrence of each of the elements defined in each system. Once each system is thus completely represented in the network, all its designated sites should be symbolically and functionally linked by the next higher designation (e.g., National Natural Landmark for Research Natural Areas, and Experimental Ecological Reserve for Experimental Reserves). Then, once each region is completely represented in the network, all its NNL's and EER's should be symbolically and functionally linked by the highest-level designation (e.g., Biosphere Reserve). Thus, the total number of Biosphere Reserves in the final network would be determined by the number of provinces and regions, and the number of RNA's and ER's needed would be more or less quantifiable at the outset.

In this proposal, the State/regional committees would be responsible for coordinating actual implementation of the national policies among the various agencies and organizations, each of which would use its existing authorities and capabilities within its limits and particular procedural requirements. If the common will exists, this effort can probably be accomplished without new Federal legislation or massive funding increases and without arbitrarily imposing heavy burdens on Federal and State agencies or private owners. Instead, it should guide them in reordering their priorities to concentrate their limited protection resources in the most valuable natural areas. All that is needed is a strong commitment to cooperation toward the common goal.

Alaska's Ecological Reserves Program: Approaches, Successes, and Problems

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Introduction

Alaska has a powerful hold on the imagination of people concerned with wildland resources. In the recent land use battles that culminated in the passage of the Alaska National Interest Lands Conservation Act (ANILCA) in 1980, the American public convinced Congress to establish many new and large conservation management areas. These included 13 new or expanded units of the National Park System and 16 new or expanded National Wildlife Refuges. ANILCA also designated 56,276,900 acres (22,784,170 hectares) of federal land as wilderness. These are in addition to the previously established National Parks, Forests, and Refuges of Alaska. Large acreages in Alaska remain in the public lands under the management of the Bureau of Land Management.

The State of Alaska has also established a system of State Parks. The larger State Parks (greater than 1,000 acres [405 hectares]) contain over 2,965,000 acres (1,200,400 hectares) (State of Alaska 1981). The State Parks established to date come from only a portion of the approximately 104-million-acre (42,105,000 hectares) state land entitlement, which is still being transferred. In addition, state Game Refuges, Wildlife Sanctuaries, and Critical Habitat Areas have been established.

As a result of all these actions, Alaska has one of the greatest concentrations of conservation management areas of high ecological quality in the world. On the other hand, the pace of resource development in Alaska is increasing. The state already accounts for nearly 20 percent of the oil produced in the United States. The state government is involved in an active program of land disposal to private ownership, often offering price discounts or other inducements. A major agricultural land clearing effort is underway. Population growth is high, with a considerable amount of physical expansion of the larger cities taking place. Several large hard-rock mineral developments are in prospect, and some large hydroelectric projects are under construction, with larger ones under serious consideration.

Given this background, what place or importance do programs to establish natural areas have in Alaska? With so much land in a natural condition, how are natural areas chosen for establishment? What have the successes of natural area programs been, and what are the problems?

Basic Principles and Organization of the Alaska Ecological Reserves Program

In Alaska, natural area activities take place under the sponsorship of the Alaska Ecological Reserves Council. This group is made up of federal and state land management and research agencies, including the USDA Forest Service, the

Bureau of Land Management (BLM), the National Park Service (NPS), the Fish and Wildlife Service (FWS), the University of Alaska, the Alaska Department of Fish and Game (ADF&G), and the Alaska Federation of Natives. The member agencies contribute to a budget that supports an Ecological Reserves Coordinator. The Coordinator works with resource specialists within the agencies to carry out the program.

Sites of interest to the program are called ecological reserves, instead of natural areas (more than 90 percent of Alaska is undisturbed enough to meet the highest of "natural area" standards). "Ecological reserve" is a general term, covering any parcel of land that has been specifically established to maintain or enhance its scientific or educational value. Various agencies use different official land classification titles to formally establish ecological reserves. This leads to some confusion over terminology. Several federal agencies, for example, establish Research Natural Areas (RNA's), which are managed in an undisturbed condition for baseline observation and study. But there are also Public Use Natural Areas, Outstanding Natural Areas, Botanic Areas, Geologic Areas, and Special Interest Areas, among other official land classifications, within the different federal agencies.

In addition, federal agencies also establish Experimental Forests, Experimental Watersheds, and Experimental Ranges. These are ecological reserves too, but of a different kind. Here, experimental manipulations of the land or resources are carried out. These range all the way from simple plant clippings to demonstrations of commercial-scale forest harvest. Usually, a substantial portion of these areas or nearby sites are held as untreated experimental control areas where the effects of the treatments can be compared.

Both are ecological reserves and are addressed in the Alaska program. But the latter are not necessarily natural areas. This concern with actively managed or manipulated areas (in addition to natural areas) is a unique feature of the Alaska program. It stems from the origins of ecological reserve activity in the state.

Origins of the Alaska Ecological Reserves Program

There was some natural area activity in the Tongass National Forest in the early 1950s (Underwood and Juday 1979), resulting in the establishment of a few RNA's. But it was not until the discovery of oil at Prudhoe Bay in 1968 that comprehensive, statewide ecological reserve assessments were made. The Prudhoe discovery brought great pressure to resolve land claims and began an unprecedented level of resource development in previously remote areas of the state. Researchers and resource managers soon realized that the informal network of study areas, whose continued availability they had counted on, would have to be recognized more officially.

Researchers soon began to circulate lists of important field study areas, areas that were thought to have good potential for supporting studies in the future, or areas of special or uncommon natural features. Underwood and Juday (1979) give a history of the successive refinement of these lists. Cooperation among agencies and between the federal and state governments was common, another nearly unique situation.

One reason for the cooperation was that few land transfers had actually been completed; land management, or at least land custody, was still the responsibility of the BLM and a relatively few other agencies over large parts of the state. Since this responsibility had never been fragmented, and a period of intense land planning was underway, it was just easier to take a statewide perspective or a resource-oriented perspective than to defend narrow agency positions. Also, a convenient mechanism for coordination existed in the Land Use Planning Commission. The Commission was active and generally respected for the expertise of its staff and the quality of the information it produced.

This era of activity culminated in a report to the Land Use Planning Commission that identified 222 sites, in all parts of Alaska, as recommended or potential ecological reserves. The Alaska Ecological Reserves Council was organized, and the Coordinator began work under the sponsorship of the Land Use Planning Commission in 1977.

The Type Needs Approach to Ecological Reserve Selection

All efforts up to the beginnings of the Ecological Reserves Council were based upon the area-by-area approach to ecological reserve selection. In this approach, lists of sites are compiled and then subjected to review by experts. Through a gradual process of refinement, the lists should converge on sites with the most outstanding features.

There are distinct limitations to this approach. The lists are no better than the knowledge the compilers or reviewers have about the sites. This is a particularly important drawback in Alaska because, even though there are many parts of the state that have been carefully studied, there are other regions that are still poorly understood. The area-by-area approach also is subject to the incorporation of arbitrarily chosen sites that are "favorite areas" of the nominator. These may not be the best areas available; the establishment of one of these in fact, may prevent the area best representing a particular feature or ecosystem from being incorporated later, since it would be duplicative.

The type needs method of ecological reserve selection was adopted with the formation of the Alaska Ecological Reserves Council. The type needs approach was developed in the Pacific Northwest and in various state "Heritage" programs (Dyrness et al. 1975) (Jenkins 1978). In this approach, lists of major natural features of a region are compiled. Some examples of these are (1) typical ecosystems such as recognized tundra, forest, wetland, and aquatic types; (2) rare or regionally uncommon species; and (3) special geologic or soil features such as caves, hot springs, dunes, etc. These natural features become the elements being sought, the "needs." The next step is to combine type needs into area needs. A particular kind of geology can be predicted to support particular kinds of plant communities or offer important wildlife habitat features. These combinations form area needs, which are still largely conceptual and described only in terms of natural features.

The next stage in the type needs selection process is an inventory of the particular region of the state or the conservation management area (National Forest, BLM Planning Area, etc.) where the natural feature type would be best be represented. The inventory, or inventories if more than one is consulted or conducted, may well change the concept and definition of the area need. The area need is a first approximation, and may not match reality as encountered in the field. If so, the necessary adjustments are made so that the set of candidate ecological reserves identified includes the type needs as efficiently as possible. Identifying alternative sites, or single localities if that is the case, is the final step before the comprehensive land use planning process.

In a typical land use plan the alternative ecological reserve sites are evaluated according to criteria of both the proposers and a resource manager responsible for land use planning. A given site may have the optimum combination of accessibility (a big problem in Alaska), high quality examples of desired type need features, and diversity to make it ideal, strictly from the ecological reserve perspective. However, it may have resource management conflict associated with it, such as mineral deposits or commercial timber potential. For the proposed area to survive in the face of actual conflicts with some of these resource development potentials, the case must be strong. Fortunately, every step of the type needs selection process has been contributing to a better understanding of the relative importance of sites that are ultimately recommended as ecological reserves.

The type needs selection process has proved to have several internal administrative advantages in the Alaska Ecological Reserves program.

1. As reserves are established, progress in establishing a complete system of areas can be measured against the work remaining to be done.
2. Remaining unrepresented natural feature types can be compared in various ways to set priorities for future action.
3. Standards are available to use in efficiently allocating time and money available to the program.

The final stages in ecological reserve establishment are site documentation (which can take a considerable amount of work and expense), and formal legal establishment action by the appropriate official. Given the requirements for careful site selection, exposure to public review in a land use plan, and the effort required in an appropriate site documentation report, the legal establishment action step does not significantly constrain the process. In fact, very considerable progress can be occurring in ecological reserves activity with few or no areas legally established for a time—which is somewhat the case in Alaska now.

Status and Accomplishments of the Alaska Ecological Reserves Program

The debate over the fate of the national interest lands produced a certain paralysis in land management decision making in Alaska at exactly the time that the ecological reserves program was beginning. As a result, the focus of the early efforts of the program involved type need planning. Also, the most important land management agency of the state government, the Alaska Department of Natural Resources, did not join the Ecological Reserves Council; most activity, with a few important exceptions, has involved federal land.

Ecological Reserves and the Forest Service

The Forest Service participates in the Ecological Reserves Council through both the Pacific Northwest Forest and Range Experiment Station (PNW) and the Alaska Region (Region 10) of National Forest management. The Forest Service has been the "glue" that has held the effort together and has contributed more money than any other agency. PNW provides office space and secretarial support for the program at the Institute of Northern Forestry in Fairbanks. PNW employed the

Ecological Reserves Coordinator through an Intergovernmental Personnel Act Assignment Agreement for several crucial early years of the program. Time and again, PNW has made special arrangements for contracts or performed other vital administrative functions that have kept the program going. Without this commitment, this interagency effort would not have survived. Prior to the establishment of the Ecological Reserves Council, the Forest Service established five RNA's on the Tongass National Forest, totaling 20,964 acres (8,487 hectares) (Federal Committee on Ecological Reserves 1977).

After the formation of the Ecological Reserves Council, the Forest Service was the first agency to begin to plan seriously for ecological reserves and take action. The action came after the establishment of the two National Forest Monuments, Misty Fiords and Admirality Island, by presidential proclamation. The authority for the President to establish National Monuments under the Antiquities Act is based, in part, on protecting features of scientific interest on the public lands. Following this rationale, a candidate RNA in each monument was selected for establishment by the Forest Service in 1980. The Red River RNA in the Misty Fiords National Monument, Tongass National Forest, was established; the Gambier Bay site in the Admirality Island National Monument was documented, but establishment action was held up until formal revisions are made to the Tongass Land Management Plan.

The Red River site is approximately 8,040 acres (3,255 hectares); it includes a stand of Pacific silver fir *(Abies amabalis* (Dougl.) Forbes) at the extreme northern limit of its distribution. Pacific silver fir, even though at the margin of its range, is vigorous, has abundant reproduction, and is represented in even the largest size classes of trees in the forest at Red River. A survey of the distribution of silver fir across southernmost Southeast Alaska was made as a part of the evaluation of alternatives in the selection process. This survey considerably improved the accuracy and precision of the range map of silver fir in Alaska.

The next major ecological reserve project for the Forest Service was the development of a comprehensive type needs list and policy statement for the Regional Plan (Juday 1981a, 1981b). Type needs were defined on a regional basis for both Southeast and Southcentral Alaska. There were four kinds of natural features on the list: (1) plant communities, (2) shrub species, (3) geologic features, and (4) animal species occurrences.

Plant community classification has hardly begun in these regions of the state; the current plant community list is admittedly incomplete, but especially for these areas (Viereck and Dyrness 1980). To include additional natural diversity that cannot currently be defined on the basis of plant community types, shrub species, whose ranges are roughly known, were included. The shrub species selected had some special feature of their ecology that made them distinctive. Some were restricted in distribution to southermost Southeast Alaska or the Haines area in the northern part of the panhandle where there is a sharp transition to the interior continental climate. Some were characteristic of open habitats, which are relatively uncommon in the dense rainforest environment of Southeast Alaska.

There are no officially listed endangered or threatened plant species in Southeast or Southcentral Alaska, and only one recommended for threatened status, *Papaver alboroseum* Hultén (Murray 1980). It is thought that even this species could be more common in high alpine habitats of northern mountains than is currently known. Only a relatively restricted set of animal species occurrences was included on the type needs list. This is because most animals are so motile that they will occur on ecological reserves chosen for other reasons in any event, or they are so wide-ranging that they can't be predictably found within the area of a typical reserve. However, some animal species are scientifically interesting and use their habitat in a particular way that allows their characteristic occurrence to be defined.

A coastal nesting and resting cliff used by the Peale's perigrine falcon *(Falco perigrinus pealei)* is on the list, as is a talus or log den of the common gartersnake *(Thamnophis sirtailis)* in southern Southeast Alaska. A disjunct occurrence of the northern pike *(Esox lucius)* in a coastal freshwater lake of the Yakutat forelands is being sought. A rocky hauling-out beach above the tide, used by the northern sea lion *(Eumetopias jubata),* and nesting and breeding occurrences of the dusky Canada goose *(Branta canadensis occidentalis)* and the trumpeter swan *(Olor buccinator)* are also on the type needs list.

One of the most interesting and unique characteristics of the Forest Service ecological reserves type needs list for the Alaska Region, is the diversity of geological features included. Some of the geologic type needs for Southeast Alaska are: geothermal hot springs, recent (less than 250 years old) lava flows, limestone sinkholes, active dunes, reversing waterfalls, alpine solifluction lobes, rotational block failure landslides, snow avalanche chutes, active fault scarps, and several different kinds of lakes. Some of the geologic features being sought in Southcentral Alaska include: tidewater glaciers with stable, retreating, and advancing terminii, active glacial outwash river floodplains, valley sideslope skree and alluvial fans, and tectonically uplifted coast. Another level of geologic diversity that is less spectacular and dramatic, but important nonetheless, is found in the many bedrock types that occur in both regions.

The type needs list has been used in the development of RNA recommendations for the Chugach National Forest Plan (Southcentral Alaska). Nine areas with a total of about 74,500 acres (30,160 hectares) are proposed in the plan as RNAs'.

The proposed Columbia Glacier-Granite Cove RNA includes the terminus of the last large glacier in Alaska (and one of the last in North America) with the potential to undergo catastrophic retreat. It is predicted that it will soon retreat approximately 25 miles (40 kilometers) in a 25 to 30 year period (Meier et al. 1980). There is a large ice-dammed dumping lake in the area and old-growth coastal forest that recently stood right at the ice front of the glacier terminus. The Harvard Glacier in the proposed RNA of the same name, on the other hand, has been advancing at the rate of several tens of meters per year. In the proposed Blackstone Glacier RNA there are stable tidewater glacier fronts, but also a major ice fall area where an active glacier overrides a cliff. A colony of black-legged kittiwakes *(Rissa tridactyla)* and pigeon guillemonts *(Cepphus columba)* is located on a rocky headland between glaciers. The Wolverine Glacier, in the proposed RNA of the same name, has been actively studied since the mid 1960s, when research began there as part of the International Hydrological Decade.

The Kenai Lake-Black Mountain proposed RNA supports a stand of hybrid sitka spruce-white spruce (*Picea sitchensis* (Bong.) Carr-*Picea glauca* (Moench) Voss). The proposed Green Island RNA is an island and associated rocks in Prince William Sound; the rocks support sea lion. The proposed Egg Islands RNA are shifting sands at the mouth of the Copper River. They were uplifted in the great

1964 earthquake and now support many nesting glaucous-winged gulls *(Larus glaucescens)*. Further up the Copper River Delta is the proposed Pete Dahl RNA. It has diverse wetland plant communities and nesting trumpeter swans and dusky Canada geese. The proposed Schwan Glacier RNA includes two small glacier systems on the rainshadow northeast side of the Chugach Mountains, and a major terrestrial glacier terminus.

Current ecological reserve activities for the Forest Service involve documenting, and possibly establishing, the Columbia Glacier-Granite Cove area before the glacier retreat gets underway. This will provide a baseline of conditions before the environment changes radically. The Forest Service is also considering a comprehensive review of potential ecological reserves on the Admiralty Island National Monument.

Ecological Reserves and BLM

BLM has been one of the most consistent supporters of the Alaska Ecological Reserves program. Project activity was begun later than with the Forest Service, but it is currently more active than any of the other agencies. More staff at BLM have become involved in carrying out ecological reserve activities than at any of the other agencies; this is how the program is intended to work and bodes well for the future. BLM has also planned for a schedule of ecological reserve (primarily RNA) reviews for Planning Areas within its districts and has programmed a modest amount of money to support the necessary fieldwork in the remote and poorly known parts of Alaska it is generally responsible for.

A type needs review was conducted for the 2.2 million acres (890,000 hectares) of the Steese National Conservation Area (NCA) and the White Mountains Nationals Recreation Area (NRA) in 1982; four sites have been documented and proposed as RNA's from these areas in the Plan. Type need planning is now underway for the Central Yukon Planning Area. In brief, BLM is doing a thoroughly professional job and has clearly established itself as a leader in this activity in a relatively short time.

The proposed Limestone Jags RNA in the White Mountains NRA has a remarkable diversity of desired type need features in this unglaciated part of the interior with warm summers. There are cliffs, caves, natural arches, emergent cold springs, and faultlines. There is a distinct limestone flora of wide biogeographic affinities, and contrasting tundras on limestone and basalt summits. Well developed white spruce forests occur too. Perigrine falcons frequent the area (Juday 1983).

The proposed Mount Prindle RNA, which stradles the border of the White Mountains NRA and the Steese NCA, is prime breeding habitat for the wheatear *(Oenanthe oenanthe)*, a passerine bird that migrates to the Old World for the winter. Mount Prindle is one of the few glaciated areas of interior Alaska and has some of the best developed solufluction lobes in the state. In the fall of 1982, the area experienced two large debris torrents (a slurry of rock, mud, organic debris, and water) that gouged deep channels down the side of the mountain. Uncommon plants include at least one lichen, and possibly a species of *Draba*.

The proposed Serpentine Slide RNA in the White Mountains NRA is marked by a recently reactivated (1981 or 1982) major earthflow covering approximately 40 acres (16 hectares). The slide is over a half mile (800 meters) long and 660 feet

(200 meters) wide. The area also contains an exposure of nearly unvegetated serpentinite, which may support locally adapted ecotypes of interior Alaska plants. Well developed bottomland white spruce and balsam poplar (*Populus balsamifera* L.) forests and successionl shrub types occur along Beaver Creek.

The Big Windy Hot Springs proposed RNA in the Steese NCA includes a pristine hot springs in a rugged canyon. Several plant species that occur in the geothermally heated soil are major disjuncts from more southerly populations. Delicate chemical precipitate rock formations are present. The area is also very important Dall sheep (*Ovis dalli dalli* Nelson) habitat. Escape terrain, generally lacking in the area, is found in an extension of the proposed RNA in the mountains to the south of the hot springs.

Ecological Reserves and State Agencies

ADF&G has contributed financially to the support of the Ecological Reserves program fairly regularly, through its Habitat Division. ADF&G is generally not a land management agency, so the work in support of the Department's objectives has focused on obtaining wildlife habitat benefit on federal lands. Many of these cases have been noted in this paper. In addition, close cooperation between the Coordinator and ADF&G staff has allowed a strong case to be made for modifications to certain proposed state land disposals that would have been needlessly disruptive of some important wildlife habitats. The relationship between ADF&G and the Ecological Reserves program is at a crossroads because of a new state administration, new Commissioner, and new arrangements for support which require contracts. If the relationship can be continued, specific studies or reports are likely.

The University of Alaska actually employs the Coordinator now. The University contributes to the program by waiving overhead charges for the position, while handling most administrative matters. In a more general sense, the members of the University community have provided invaluable expertise on particular projects. University researchers and educators are prime sources for leads to areas, data about them, and help in fieldwork. Usually, University people will donate time to a field project if the transportation and logistic support can be provided. There has been support within the University administration for requesting part-time state funding for a Research Areas Coordinator which was approved by the 1983 session of the State Legislature.

The Alaska Department of Natural Resources has a program, on paper, for State Preserves, a unit of the State Park System. If these were larger than 640 acres (260 hectares), they would require legislative approval. While the State Preserves program concept was approved in mid-1982, implementation may take some time. The Department has begun to change its earlier policy of non-participation in the Ecological Reserves program, and a closer relationship may be possible.

Ecological Reserves and FWS and NPS

The FWS has established 10 Research Natural Areas in Alaska over the years. Two of these are very large and may be slightly beyond the scope of the objectives of the Ecological Reserves program. The Andrew Simon RNA on the Kenai National Wildlife Refuge is 830,000 acres (336,000 hectares), and the Firth River-

Mancha Creek RNA is 520,000 acres (210,500 hectares). However, four other RNA's on Wildlife Refuges in Alaska total only 70 acres (28 hectares). It is most likely that all 10 RNA's were established before the formation of the Ecological Reserves Council; it is somewhat difficult to be certain because the establishment documents are brief and the dates of proposal versus action on them are sometimes obscure.

The FWS financially supported the program for the first years, but has not done so recently. While coordination between field-level staff and the Coordinator has generally been excellent, FWS in Alaska made a policy decision to handle its responsibilities for ecological reserve matters alone. ANILCA requires the FWS to produce conservation/management plans for the 16 new or expanded National Wildlife Refuges by 1987. Ecological reserves or Research Natural Areas may be addressed in them, but evidently not in coordination with the existing program and not in the detail now being done elsewhere in Alaska.

The NPS contributed financially to the program for the first year, but has not done so since. NPS policy makers do not see ecological reserves as a high priority. There is a widespread feeling within NPS that the Parks are already protected in any case, so ecological reserve designation is duplicative and means little. There has been support for the program within the science section of the Alaska NPS office, but science programs have been virtually eliminated from the Alaska NPS budget. Some field-level staff in Parks that were established and have been heavily used for research, such as Glacier Bay, support the effort because they often work with long-term study areas. Hugh Miller Inlet in Glacier Bay National Park was the subject of a site documentation visit on behalf of the program in 1979. It was first visited and marked for successional studies in 1917 by A.S. Cooper. The successional study there will be updated in the future. The NPS is also on a planning schedule for the new units of the National Park System. These, too, will largely be completed without much coordination with the Ecological Reserves program.

Major Problems

There are two major, and worsening, problems for the Alaska Ecological Reserves program. The first is lack of money. The consequences of not solving this problem are obvious. The relatively predictable sources of funding, from the contributions of the regular member agencies of the Ecological Reserves Council, currently total only about half of the yearly budget. No other major sources of funding appear to be available. It is ironic that when the policy paralysis finally cleared up and the work demand expanded greatly, the funding appears to have shrunken considerably, perhaps below the minimum necessary to sustain the effort.

The second major problem is the non-participation of the FWS, the NPS, and the Alaska Department of Natural Resources. The first two agencies manage major portions of the state. Even if they choose not to maintain ecological reserve activity themselves, the program in the rest of the state must take into account the kinds of natural features that occur within the Parks and Refuges they manage. There is some reason for optimism that the relationship between the Ecological Reserves program and the Department of Natural Resources will improve, possibly resulting in a serious review, for the first time, of state land for ecological reserve establishment.

A certain momentum has been built up in the program. If the program can obtain its funding, then real progress, including, finally, establishment of areas, should be happening soon. If not, it was an interesting and useful experiment.

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Cooperative Federal-State Natural Area Identification and Management on Federal Lands

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In Indiana, and in most of the midwestern states, the most natural land remaining in sizeable acreages is in public ownership. The State of Indiana's Department of Natural Resources owns large tracts managed by a number of Divisions, including Fish and Wildlife, State Parks, Reservoirs, and Forestry. The Federal Government also owns large tracts of natural land. Some of the federal agencies owning large tracts of land include the U.S. Forest Service (Hoosier National Forest; 185,000 acres [74,925 ha]), National Park Service (Indiana Dunes National Lakeshore; 12,500 acres [5,062 ha]), U.S. Fish and Wildlife Service (Muscatatuck National Wildlife Refuge; 5,000 acres [2,025 ha]), Department of Defense and Army Corps of Engineers (Jefferson Proving Grounds, Camp Atterbury, several reservoirs, Charleston Arsenal, Fort Benjamin Harrison).

Of these large acreages, only a fraction remains in an undisturbed or relatively-undisturbed condition, even though the land is still much more natural than most privately owned land in Indiana. Within the Indiana Dunes National Lakeshore, for example, large portions have been disturbed in the past by sand mining, drainage, cultivation, and fire suppression. Within the Hoosier National Forest, most of the acreage was heavily cut over or farmed in the past. The Muscatatuck National Wildlife Refuge was created from farm land in river bottoms in southeastern Indiana.

Within these and other federally owned areas, however, there still remain a number of high quality natural areas. Some of these have been known for a number of years, such as the Pinhook Bog National Natural Landmark, and a number have been found following the completion of inventory efforts.

In the Indiana Department of Natural Resources, the Division of Nature Preserves is charged with inventorying and trying to preserve the last remnants of pre-settlement Indiana, including the habitat of endangered and threatened plants and animals. Dedicated nature preserves are provided by law with in-perpetuity protection. To date, sixty-eight nature preserves, totalling approximately 10,000 acres (4,050 ha), have been dedicated. These preserves are in a variety of ownerships, including private (organizations such as The Nature Conservancy), county, city, and state. The Division of Nature Preserves also works with owners, including federal agencies, who own natural areas but are unable or unwilling to dedicate land. The Division assists with inventory, protection, management, and other natural area related considerations.

For the most part, the various federal agencies are equally concerned and cooperative when it comes to protection of natural areas. A number of agencies already have protection mechanisms in place. The National Natural Landmarks program is administered by the National Park Service and recognizes special areas of national significance regardless of ownership. The U.S. Forest Service, through "Research Natural Areas" designation, and through the planning process undertaken for each national forest, also tries to protect special areas. For the Hoosier National Forest, one goal is "to protect areas of unique or outstanding scientific, biological, and geological significance." This is done by a type of designation, protecting the site from cutting and other disturbances, and includes areas up to several hundred acres in size. Wilderness designation is also a possibility, and the Charles Deam Wilderness has recently been designated on the Hoosier National Forest.

The Division of Nature Preserves has been working with (or trying to work with) the various federal agencies, to locate, evaluate, protect, and manage natural areas. Ideally, natural area protection in a state-federal cooperative effort would include a cooperative agreement or memorandum of understanding between the agencies, a natural areas and special species inventory, registration or designation to protect the area, and management, if needed. We are close to this ideal with the U.S. Forest Service in Indiana. A statewide natural areas inventory, being coordinated by the Division of Nature Preserves, is underway, and includes the Hoosier National Forest. The Indiana Natural Heritage Program is actively seeking out and entering into its data base information on significant areas and rare species. Efforts are underway to contract with the Forest Service to complete the natural areas survey in the near future. Thus far, three of nine U.S. Forest Service counties have been inventoried, and all information has been given to the Hoosier National Forest planning team and the District Rangers. Negotiations are underway to formally (with a cooperative agreement) register these natural areas. The truly significant sites, if eligible, might be considered for Research Natural Area status. The other natural areas will be designated and protected as "planning goal H," as "unique or outstanding areas . . . of significance."

Further successful cooperative efforts between the state and the Forest Service include land exchanges. The Forest Service will be transferring to the state an addition to the Yellow Birch Ravine Nature Preserve in one of these exchanges. The Nature Conservancy is also assisting the Forest Service in some of these exchanges by purchasing natural area inholdings and exchanging them for disjunct tracts that are surplus to Forest Service needs. The Department also reviews all land proposed for disposal by the Forest Service to insure that significant areas are not involved.

Similar cooperative efforts have been undertaken with the National Park Service. The Division of Nature Preserves and the Natural Heritage Program work closely with the Park Service Science Office staff on inventories and the sharing of information. A Memorandum of Understanding is being drafted to formalize this relationship and provide for the registration of natural areas.

The Park Service and the Department have cooperated on several prescribed burns at Hoosier Prairie Nature Preserve. And a land trade is underway that will mutually benefit both agencies and natural areas preservation as well. The Department of Natural Resources acquired a heron rookery from the Department of Corrections and plans to exchange it with the Park Service for an addition to the Hoosier Prairie Nature Preserve.

Some efforts with other Federal agencies have not been as successful. In several cases, inventories have not been permitted or encouraged. In other cases, where an inventory was permitted, protection of significant sites was refused. However, we are optimistic that this situation will improve.

In summary, in Indiana and in other states as well, it is important to work closely with federal land-holding agencies in order that the few remaining natural areas are identified and protected. We are fortunate in Indiana to have had a high degree of cooperation and success so far.

Recreational Management For Newly Established Natural Areas

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Introduction

Proposed nature reserves that are not presently in the public domain have several unique planning problems. These include the removal of land from local government tax base, implications for the management of ecological systems on surrounding land (outside threats), and problems with altering traditional patterns of use on the land if they conflict with goals for natural area management. The University of California Natural Land and Water Reserves System (NLWRS) faces these problems often in the effort to secure research and educational natural area laboratories within reasonable travel distance of the nine University of California (UC) campuses. Problems with tax base removal are handled individually on reserves, with most local governments in support of University goals. Outside threats perhaps offer the biggest problem because control over surrounding development and land use is often not possible or welcome (U.S. National Park Service 1980). Indications from the system-wide NLWRS planning office are that close to 80 percent of their time is spent on dealing with off-site problems.

Management problems that are most often dealt with on site after initial establishment of a reserve (aside from ecological stability) include inadequate infrastructure, over use, and traditional recreational activities that are often not compatible with reserve planning goals (Leopold 1968). Infrastructure problems might arise because proper resource information was not originally collected and roads or trails might not be designed properly in relation to topography, and soil types not considered to avoid erosion or compaction. Over use of popular natural areas is very common, and the adage that "love can kill" is very appropriate (Wilkes 1977). Undesirable recreational activity (in relation to natural area goals) is very common on what has been previously open land because it is hard to find areas for free target practice, off-road vehicular use, or partying.

Stebbins Cold Canyon

All of the above discussed problems came with the recent acquisition of the Stebbins Cold Canyon Reserve by the U.C. Davis Natural Land and Water Reserves Committee. Stebbins Cold Canyon Reserve consists of 277 acres (112 ha) of canyon habitat located on the eastern edge of the California Coast Range, about three miles from Winters, Solano County. It was acquired by the UC in August, 1979, as part of its Natural Land and Water Reserve System, the first such reserve associated with the Davis Campus. It was acquired because of: (1) its proximity to the Davis Campus (25 minutes by automobile); (2) its wild and diverse nature; (3) its accessibility; (4) its history of use by classes from UC-Davis; and (5) its common border on three sides with lands owned by the U.S. Bureau of Land

Management (BLM) and the California Department of Fish and Game (CDFG). The latter situation makes roughly 1.2–1.5 square miles (3–4 km^2) of public wildland available for University use, especially because the University land ties the BLM and CDFG parcels together (Figure 1).

Off-Site Planning Problems

As can be seen in Figure 1, Cold Canyon is fortunate to be located in an area with substantial public ownership. The BLM has been very cooperative with discussions of natural area management for their adjacent lands, with possible transfer of some of these lands in the future to the University. Because recently acquired surrounding lands of the CDFG were causing access problems through the reserve for hunters, a preliminary agreement was just reached. Basically, the CDFG land was purchased to provide access to lands east of the reserve, and it was just a particular of acquisition that some land adjacent to the reserve was included in the land purchase. CDFG has agreed to recommend to staff and the Fish and Game (F&G) Commission to (1) change status of F&G land at the entrance of the canyon from wildlife area to ecological reserve; (2) close the ecological reserve to hunting; (3) encourage access to quail hunting at the Putah Creek expansion area (near the reserve) through routes that would avoid the reserve; (4) stop deer hunting in the watershed (for safety); and (5) enter into a memorandum of understanding between CDFG and UC-Davis to manage the land as an ecological reserve.

The last remaining outside threat of immediate necessity is a proposal by Solano County to build a campground and recreation area near the reserve entrance. Solano County has agreed to work with UC-Davis in developing an appropriate environmental impact report section detailing UC-Davis concerns and in designing the park to restore natural vegetation and lessen visitor impact on the reserve. Also, their posture against firearms in the area and the offer of rangers from the park to help patrol the reserve could be helpful.

On-Site Recreational Management

Because Stebbins Cold Canyon was the first reserve acquired by UC-Davis, there was substantial interest on campus in getting the area quickly under management for research and education. There were close to a dozen research projects planned and a steadily increasing visitation to the site for classes and teaching. At the same time, some traditional areas of recreation were conflicting with these uses. Camping, fire building, and partying had little respect for research plots. Dogs were continually introducing domestic diseases through feces and disturbing small mammals. And, target practice and hunting access were thought to have an uncontrolled impact on monitoring population levels.

Recreational management options for the UC-Davis NLWRS Committee on Stebbins Cold Canyon included four basic options: (1) close the area totally to non-university related research and teaching; (2) immediately begin a strategy to reduce unwanted recreational activity through simple and direct signing and fencing; (3) begin a slowly evolving public education program with environmental education, gradual removal of unwanted activities, and a general tolerance for disturbances; and (4) allow existing use to continue.

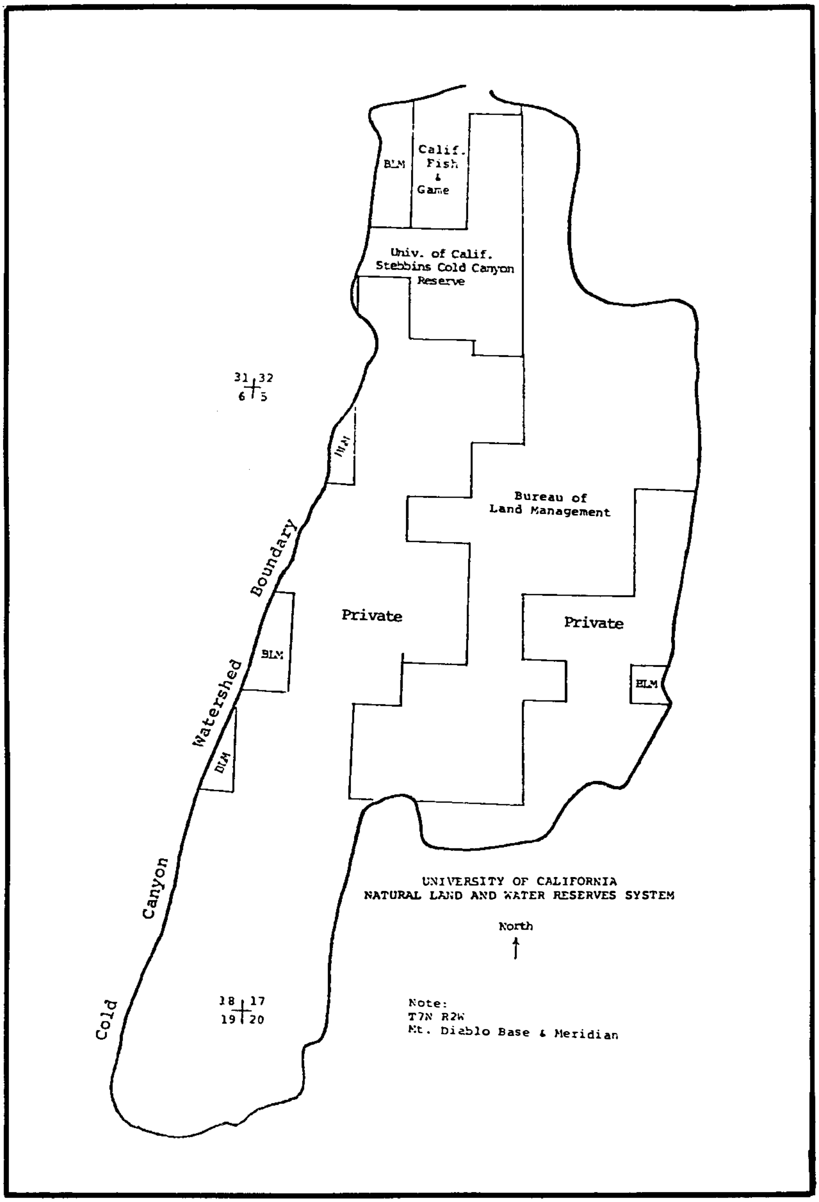

Figure 1. In Figure 1, the relationship of the UC Stebbins Cold Canyon Reserve to private and public land in the Cold Canyon Watershed can be seen. The site borders Bureau of Land Management land to the east and west, while California Deparment of Fish and Game lands were recently acquired to the north of the reserve. Private land holdings are to the south in the headwaters of the canyon.

The last option was considered unacceptable because of the research and education goals for the area. Closing the area to non-UC use was also considered unacceptable and not in tradition of the reserve system. Primarily because of pressure to get the reserve functioning rapidly for research, but because of a lack of resources for a fully functioning on-site environmental education program, a decision was made to strike a balance between options 2 and 3. A fence and gate was installed by CDFG on their property at the entrance to the canyon, which completely eliminated off-road vehicle use (a policy of CDFG). Imposing entrance signs with little writing but very graphic symbols for what was prohibited (Figure 2) were designed by the UC-Davis NLWRS Committee. Additional NLWRS signs throughout the area more fully explain the purpose of the reserve and its role in research and recreation.

Recreational Management Program Effectiveness

To assess the effectiveness of recreational management over the first full year of operation, a survey was begun on use and activities. The original gates and signs were installed in the fall of 1981. In November, a direct observation study was begun where the reserve was visited twice weekly on a random schedule for

Figure 2. Entrance signs at Stebbins Cold Canyon were designed to state as simply as possible the status of the area and recreational activities that were not acceptable. Smaller system-wide NLWRS signs are scattered throughout the reserve to explain in greater detail the purpose of university research. Seen in this photo is the first level of vandalism to occur on the signs.

one-and-one-half hours and all observed use and activity was recorded. A student walked the entire length of the reserve trail and recorded visitors numbers, group size, and activities (including vandalism and presence of dogs, guns, motorbikes, and campfires). In March, 1982, a register was installed by Wes Weathers, the reserve manager. From March through June, correlations between the register and direct observation were made. Funding for the direct observation was then phased out on the start of the new state fiscal year on July 1.

From the survey information, overall visitor use during 1982 was estimated at 4,011 total visitors (Figure 3). Weekly visitor use and daily visitor use were also observed and recorded. Over 60 percent of visitor use is on the weekends, with Sunday being the most heavily visited day of the week. Visitor use drops to the low point of the week on Monday and climbs steadily as the week progresses. Fifty percent of daily use is in the mid-afternoon between 1 and 5 p.m. Twenty-five percent of use occurs before noon, while evenings past 5 p.m. are mostly visited during the lengthened days of summer. Overnight visits are rare but do occur.

Visitor use by group size and type of activity was also recorded. Approximately 75 percent of visitors were individuals or pairs. Groups of six and above included classes and organizations such as environmental groups, boy scouts, and social clubs. Nature appreciation related activities represented close to 50 percent of site

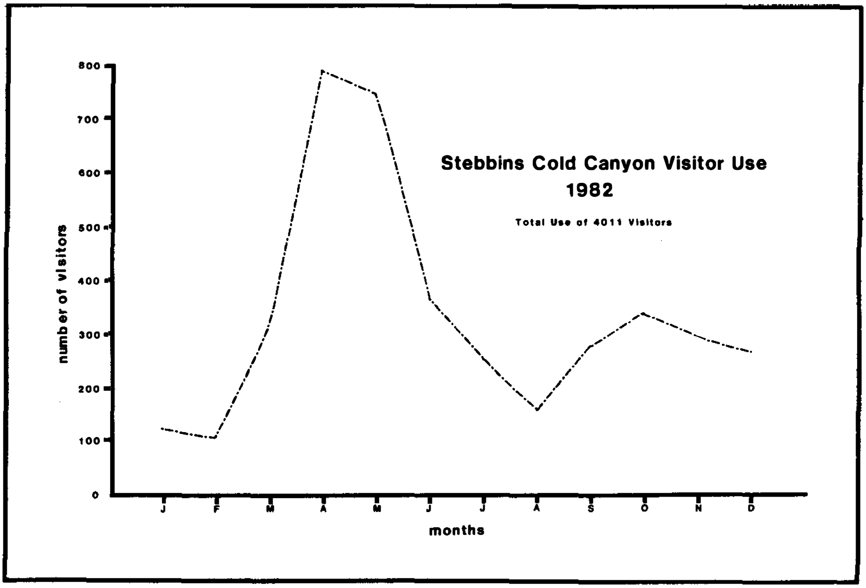

Figure 3. Overall use of Stebbins Cold Canyon during 1982 totalled 4,011 visitors. The most heavily visited months are in the early spring when the weather warms and wildflowers and biological activity of spring arrive. Use gradually diminishes over summer to a low point of just over 100 visitors a month in August when hot weather creates extremely dry conditions. Activity increases in the fall with the return of classes and research activity and hits the lowest point of the year during the rainy months of January and February.

use. Research and teaching related activities represented approximately 25 percent of use, while the remaining 25 percent were pure recreational activities. Recreational activities included target practice, camping, partying, alcohol and drug consumption, running dogs, motor biking, and vandalism.

A primary hypothesis in the planning for quickly establishing research and education in the reserve was that recreation would be displaced, that anger would result, but that the public would eventually understand and the anger would subside. This hypothesis was the basis for both the design of the reserve signs and the decision to order several of each type of sign. The assumption was that vandalism would be severe on the first signs but lessen on later ones. This rationale is obviously more appropriate for a rural site where considerable effort is needed to travel to the reserve. In urban natural areas, vandalism on signs might continue simply because of easy access and continuous opportunity. As can be seen in Figure 2, entrance signs received a high level of vandalism from the beginning. Vandalism spread throughout the smaller signs, with closed area signing receiving the highest levels.

However, preliminary indications are that the strategy for removing unwanted activity is working and that vandalism is on the decline. The results from observation and register correlation covering the period from late 1981, when the reserve was first gated and signed, through early 1983, show a steady decrease in sign vandalism, presence of dogs, target practice, and camping. Eight months after initial on-site establishment of the reserve, new signs were installed to replace damaged ones. After very violent reaction to the first signs, it was pleasing to see extremely reduced damage to the second group of signs over a similar time period.

Conclusion

The uncompatibility of certain recreational activities on nature reserves is very difficult for some recreationists to understand. Flora susceptible to tramping or fauna that cannot tolerate disturbance or human activity are not primary considerations of those participating in undersirable recreational pursuits. At the same time, managers who ignore the signifcance of recreational activity in master planning the future of a reserve are likely to suffer the consequences of the nonhumanist view.

An interesting aspect of Stebbins Cold Canyon is that it is located in an area of great versatility for conservation and recreation. The importance of the reserve is demonstrated by its status as the only reserve in the Southern Coastal Range segment of the approximately 800,000 acres (324,000 ha) of public land in the BLM Ukiah district. The closest reserves are the Northern California Coast Range Reserve and Kings Range Conservation Area, 100 miles (160 km) and 200 miles (320 km) respectively to the north. Further, displaced recreation can take advantage of five designated recreation areas within 10 miles (16 km) of the reserve, including Lake Berryessa, Lake Hennessey, Los Posadas State Forest, Putah Creek Fishing Access Area, and Solano Lake County Park. Hundreds of thousands of public BLM acres are open to hunting, and, within five miles (8 km), three hiking areas offer natural yet unrestricted recreation access. These are Mix Canyon, Gates Canyon, and the west slope of Berryessa to Pope Valley.

The test of the success of the area as a research and teaching laboratory worthy of displaced recreation has yet to be proved, however. After reasonable recovery of the ecosystem and populations, consumer satisfaction surveys (Chanter and Owen 1976) of the researchers and teaching user will be a high priority for the NLWRS Management Committee.

Lastly, although unwanted activity has been reduced on the reserve, the levels of safety required for unrestricted research have yet to be attained. Although females represent 50 percent of general enrollment at UC-Davis and over 50 percent of the enrollment in some of the educational programs utilizing the reserve, female visitors make up only one-third of total use. Further, of individual trips recorded, close to 95 percent are male. Females will rarely visit the reserve alone, and although this is a national trend (Golden and Pilcher 1982), it is disappointing. An encouraging sign was an increase in singular female trips in the fall of 1982 as beer drinking and target practice decreased.

Acknowledgements

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Special Presentation:
Preservation of the Tallgrass Prairie: Opportunities for Action

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Today I am happy to welcome you to the central grasslands, to the land of the tall grass. Before European settlement, North America had nearly one billion acres (405 million ha) of grassland, mostly here in the middle of the continent, a region where winds blew through undulating grass from Mexico to southern Canada (Lemon 1970). From west to east this central grassland is divided by ecologists into shortgrass, midgrass and tallgrass prairie on the basis of dominant vegetation. The tallgrass or true prairie was approximately 250 million acres (101.2 million ha) of open country stretching from southern Manitoba to Texas including parts or all of Minnesota, North and South Dakota, Wisconsin, Nebraska, Iowa, Illinois, Indiana, Ohio, Missouri, Kansas and Oklahoma (Duncan, 1978). Here the dominant plants were warm season tall grasses—big bluestem, indiangrass, switchgrass and prairie cordgrass—growing from 4–6 feet (1.2–1.8 m) tall under usual conditions but reaching 8–12 feet (2.4–3.6 m) on optimal lowland sites. The plant community included many forbs, with composites, legumes, milkweeds and evening primroses particularly well represented. These wildflowers splashed the prairie with ever changing color from early spring until fall.

Typical wildlife of the prairie included large grazers: bison and wapiti; large predators: prairie wolf, coyote, and cougar; rodents: prairie vole, harvest mouse, franklin ground squirrel, and plains pocket gopher; and ground-nesting birds: greater prairie chicken, upland sandpiper, dickcissel, and eastern meadowlark. A rich diversity of grasshoppers, beetles, butterflies, bees, and flies were part of the arthropod fauna.

Three features of the mid-continent environment most important in molding grassland communities were: limited and unreliable moisture, periodic fires, and seasonal temperature extremes. Moisture was more limiting to the west, while fire was most important in the eastern tallgrass prairie. As an adaptation to these conditions, more than half of the biomass and all of the perennial parts of most prairie plants are underground, and many prairie animals are fossorial. For prairie life, soil is a major protection from climatic extremes and fire.

Diversity in the prairie community, though not overpowering like the variety of a tropical rainforest, has been described by many students of the prairie. The pioneer authority on grassland vegetation, J. E. Weaver (1954) described the prairie "... as an inextricable mass of endlessly variable vegetation. One glories in its beauty, its diversity, and the ever changing patterns of its floral arrangements. But he is awed by its immensity, its complexity, and the seeming impossibility of understanding and describing it."

Aldo Leopold (1966) also wrote of diversity in the prairie ecosystem, "The black prairie (soil) was built by the prairie plants, a hundred distinctive species of grasses, herbs, and shrubs; by the prairie fungi, insects, and bacteria; by the prairie mammals and birds, all interlocked in one humming community of cooperations and competitions, one biota."

Diversity in the prairie had many dimensions. There was a horizontal dimension, the geographic diversity in species composition and in ecotypes within species over the whole central grassland (Carpenter 1940, McMillan 1959). At a smaller scale there was the mosaic of species in each prairie stand. Each prairie also had a vertical dimension of diversity with upper photosynthetic layers and lower root and decomposer layers; had a time-related dimension with daily, seasonal, and yearly changes in species composition and/or activity; and had variety related to ecological function as each species fit into its own unique niche in the food web and other interrelations among species (Allen 1967, Weaver and Fitzpatrick 1934). Thus by differentiation in space, in time, and in function many different forms of life shared the landscape we call prairie.

Those who observed the original prairie described it in many different and often contradictory ways—vibrant, still, lonely, exciting, monotonous, complex, barren, rich and many more. Early European explorers, coming from forested regions, first encountered the prairie with ambivalent feelings. Some, like Lieutenant J. W. Abert (1848), could appreciate the prairie. He crossed Kansas in the summer of 1846 and described the beauty of the prairie landscape, the country "verdant with the rank growth of the 'tall grass.' " Other reports, such as those from the expeditions of Zebulon Pike and Stephen Long, described the barrenness and, assuming that land without trees was too poor for agriculture, included most of the grassland in the Great American Desert. Men like Pike believed that the grassland would always be wasteland, but others, like the English naturalist John Bradbury, saw agricultural potential in the grassland region (Whitney et al. 1979).

The tallgrass prairie became the richest agricultural region in our nation. The prairie soils, unlike those of the drier grasslands to the west, were generally moist down to the underground water table and yet were not so leached as most forest soils. The large annual turnover of vegetation mixed with the soil and created a topsoil that was usually deep and rich in humus and nutrients (Weaver and Fitzpatrick 1934).

At first, settlement on the prairie was slow as caravans moved across this "barren" land from eastern settlements to the west coast. But once the agricultural richness of prairie soil was realized and the steel plow was available to turn prairie sod, a biological revolution was rapidly accomplished on the tallgrass prairie. The communities of bluestem, switchgrass, evening primroses, milkweeds, asters, and prairie clovers were replaced with new communities of corn, wheat, oats, and other introduced crop plants of managed agricultural ecosystems.

The development of this highly productive agricultural region from the tallgrass prairie attests to the ingenuity of the human species, but the completeness of the biological transformation is a cause for concern. Of the 250 million acres (101.2 million ha) of original tallgrass prairie, today less than 2 percent remains in native grassland and much of this is in small relic patches along roadsides, on railroad rights-of-way, in old cemeteries, or on small plots unsuitable for cultivation. The only large area of native vegetation is rangeland on the shallow rocky soils of the Flint Hills of eastern Kansas and the Osage Hills of northern Oklahoma. All of these areas are modified; none includes a complete prairie ecosystem. A number of important animals have been extirpated from the prairie region. Most of the larger parcels of native vegetation are managed for economic production as rangeland. This agricultural management regime has had an effect on the plant community, litter accumulation, and microenvironments for some of the smaller animals. Overgrazing accentuates such changes, but there are differences in the plant and animal community of a well-managed productive range from that of a natural tallgrass prairie (Dix 1959, Drew 1947, Hutchinson et al. 1968, Reed 1972, Risser et al. 1981).

With the almost total loss of the tallgrass prairie, it became an unknown natural community to most Americans, even to many who now live in the prairie region. In literature, mythology, and traditional children's stories, wildlife and wild nature are usually associated with forests. Grassland is associated with agricultural production. Few people are able to distinguish between a native prairie and a grassy ruderal field or a highly modified pasture. However, in recent years there has been a renewed interest in prairie as a part of the natural heritage of North America.

The idea of preserving a portion of the grasslands in their natural state was proposed as early as the nineteenth century by George Catlin, artist and explorer, who advocated that a national park be established to "preserve for the Nations some corner of an unspoiled West against the ravages of civilization" (Whitney et al. 1979). In 1930, Dr. V. E. Shelford, with support from the Ecological Society of America, proposed to the National Park Service that it preserve a sizeable area of native grassland (Coggins and McCloskey 1977). The Canadian government has recently initiated preservation of a large tract of northern midgrass prairie in a national park. However, most attention and concern has focused on the tallgrass prairie because no preserve could include all of the grassland types and the tallgrass prairie is most in danger of complete modification.

To preserve a prairie means to ensure that the highest priority for a piece of prairie land is not economic production but maintenance of the natural community and the native species. This can be done by private agreement or by local, state, or federal government action. In the last few years, some state governments in the tallgrass region, seeing that their natural heritage has all but disappeared, have initiated programs to preserve prairie relics. A number of private organizations have programs of prairie preservation, most significantly The Nature Conservancy with its Katherine Ordway system of prairie preserves. These state and private preserves are located through much of the tallgrass prairie region and preserve some of its geographical diversity. However, less than 50,000 acres (20,250 ha) of tallgrass prairie is protected.

The largest of these tallgrass prairie preserves is only 8,616 acres (3,489 ha), the Konza Prairie managed by Kansas State University. There is no preserve large enough to maintain the local diversity of the ecosystem. To reintroduce the large prairie animals and allow for movements and grazing patterns that would be seminatural would require a single preserve of at least 60 to 150 thousand acres (24,000–61,000 ha). Large mammal ecologist David Kitchen, in an unpublished paper prepared for the Scientific Advisory Panel to Save the Tallgrass Prairie, stated: "To have a herd of 1,000 bison would require fencing at least 60,000 acres . . . if other species are to be maintained at reasonable levels (400–500 wapiti, 500–600 pronghorns and 500–600 deer). . . . However, an area of 150,000 acres will provide not only more room and forage, but will also allow more natural movements of bison (and all large herbivores). This should approximate more closely the natural situation of pre-European settlement times."

The Scientific Advisory Panel also concluded that a large preserve would provide additional benefits, including: (1) a greater variety of habitats and communities preserved and replicated; (2) an extra carrying capacity to provide for years with poor growing conditions; (3) better buffering against perturbations from outside such as the encroachment of exotics or the effects on the preserve of management practices on neighboring land; (4) preservation, over the long term, of a larger proportion of the initial community diversity; and (5) a lower per-acre cost of maintenance.

Most proponents of a large prairie preserve have concluded that only the federal government has the resources for such a project. Coggins and McCloskey (1977), in a study of federal agency programs for preserving natural areas, concluded that the National Park Service was the best agency to preserve a large sample of the tallgrass prairie. In the latest study by the National Park Service (1975), only three sites were considered suitable for restoration and preservation, down from six sites 15 years earlier. All of these sites are on private land in Kansas and Oklahoma that would have to be acquired by the federal government.

The first bill to establish a tallgrass prairie park was introduced in Congress in 1961 after the National Park Service had recommended a 57,000 acre site in Pottawatomie County, Kansas. This bill was killed by political controversy (Duncan 1978). The controversy heated again in the 1970s when a pro-park organization, Save the Tallgrass Prairie, was organized and bills to establish a prairie park were introduced in each session of Congress. An anti-park organization, Kansas Grassroots Association, vigorously opposed these bills. Although there was support in previous federal administration and within Congress, most members of the Kansas congressional delegation did not give their support, and the bills to establish a prairie park all died. Today, no large area has been set aside to preserve the tallgrass prairie ecosystem.

Both proponents and opponents of a large national tallgrass prairie could benefit from such a preserve as it would be a base line to monitor the effects of land use practices, would provide a reservoir of biological species and genetic diversity, would provide a link with the past and a monument to the natural heritage of the region, and would have educational, aesthetic and recreational value. Both proponents and opponents agree in their appreciation for the prairies of the Flint Hills and their dedication to the conservation of these grasslands. But areas of common interest have not lessened the controversy because of important disagreements and the emotional involvement of persons on both sides.

The two groups have different concepts of the prairie to be preserved. Members of the Kansas Grassroots Association view prairie as productive rangeland, the most important component of which is grass. They justify the benefits of private management in preserving prairie by pointing to the high productivity of the range today and suggesting that the grass is in better condition now than at the time of settlement. Members of Save the Tallgrass Prairie are concerned with the prairie as a diverse natural ecosystem in which each species fills a niche, including some important species that now do not exist in the Flint Hills. Although they are concerned with the conservation of rangeland, an agricultural ecosystem appropriate for most of the Flint Hills, they believe that some land should be dedicated to the restoration and maintenance of the natural ecosystem.

Members of the Kansas Grassroots Association place high value on private individual rights, have great antipathy toward intrusions by the federal government, place little value on land uses that are not economically productive, are concerned to protect the rural but not necessarily a wilderness landscape, and feel that the greatest dangers to the prairie would come from government management. Members of Save the Tallgrass Prairie are concened about the public interest in a natural resource of national and international importance, feel that local citizens can cooperate with the federal government in developing mutually beneficial programs, place great value on educational, scientific and aesthetic uses of land, are concerned to preserve a wilderness prairie landscape, and feel that the greatest dangers to the prairie come from the intrusions of future development and the effects of future agricultural technology and practices dedicated to improving grassland productivity.

Compromise between these two positions is difficult. Opponents of a large preserve have suggested a prairie parkway with scenic overlooks and small preserves as an alternative. Members of Save the Tallgrass Prairie do not accept this compromise because, although it is a step in the right direction, it does not accomplish their main objective, the preservation of a tallgrass prairie ecosystem.

Members of Save the Tallgrass Prairie and other conservation organizations have recognized the valid and understandable concern for persons whose land would be taken for a national tallgrass prairie. Therefore they have offered a compromise on the method of land acquisition, proposing that the land be acquired over a long period of time from willing sellers with the National Park Service having right of first refusal at the seller's price. But Kansas Grassroots members feel that any federal purchase of land would be a "foot in the door" which would lead to federal intervention and developments that would disrupt their way of life. One group is fighting for what it views as an endangered lifestyle in a beautiful countryside, while the other is fighting for what it views as an endangered natural ecosystem that is not only of national but also international significance.

Today, we in Save the Tallgrass Prairie recognize that the present political climate and the national park policy of the present federal administration preclude the establishment of a prairie preserve by the federal government in the near future. However, many opportunities for action to work toward this goal are left open. Although preservation of a large sample of the tallgrass prairie ecosystem remains a primary goal, we believe that now is an opportune time to concentrate our efforts on education about prairie and its importance and on preserving rangeland and small prairie preserves to keep options for the future open.

Education is essential to develop the broad interest and support necessary for prairie preservation. Over the next few years we will be devoting our efforts to various educational projects, through the media and the classroom, by educational radio transmission to cars that are passing significant prairie areas, and through prairie interpretation at highway rest stops combining music, history, poetry, art, and nature. We will be investigating the potential for public access to small areas of tallgrass prairie on public lands so that people can see and learn about prairie.

We will also be giving increased support to private land conservation and will encourage the maintenance of ranching in the Flint Hills by seeking conservation easements to protect pastoral landscapes and supporting programs to help young ranchers get established. We will encourage the private preservation of small prairie areas through dedication in the state natural and scientific areas program. We seek the support of ranchers and all citizens to prevent development in the Flint Hills that will diminish the ranching lifestyle and the open grassland.

We are open to local, state, and private options and creative flexible solutions to conserve and to preserve a natural resource that is important to us all. The tallgrass prairie region must be conserved as a rich agricultural region. Rangeland and the ranching lifestyle in the Flint Hills must be protected. But we are also convinced that we must find a way to restore and preserve a large sample of the natural tallgrass prairie ecosystem. Today we seek your support and your counsel in our efforts. If we are to preserve prairie for ourselves and our children and grandchildren, we must all cooperate in maintaining this important part of the biological heritage of our planet.

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Registered Attendance

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Guy Baldassarre, James R. Davis, Ralph Edward Mirarchi, John Pritchett, David Wielicki

ALASKA
Michael A. Barton, Dirk V. Derkson, Win Green, Glenn Patrick Juday, Junior D. Kerns, Stan Moberly, Margaret R. Petersen, Bob Phillips, Keith M. Schreiner, Ronald O. Skoog, Bill Steigers

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